ISSN 2695-0243
DOI 10.47451/col-036-2025

EUROPEAN SCIENTIFIC e-JOURNAL

ISSUE 36 MAY 30, 2025

ACTUAL ISSUES OF MODERN SCIENCE

Proceedings of 2025 EIID International Conference

EUROPEAN SCIENTIFIC E-JOURNAL

ISSN 2695-0243

ISSUE 36

ACTUAL ISSUES OF MODERN SCIENCE

Proceedings of 2025 EIID International Conference

DOI 10.47451/col-036-2025

European Institute for Innovation Development
EU, Czech Republic
2025

Actual Issues of Modern Science. Proceedings of 2025 EIID International Conference. European Scientific e-Journal, 36. Ostrava: European Institute for Innovation Development, 2025. — 159 p.

DOI 10.47451/col-036-2025

Scientific Supervisor of the Issue
Alexander Buychik
Doctor of Economics, Ph.D. in Social Sciences

Editor-in-Chief of the Issue
Maksim Bakhtin
Full Professor, Doctor of Philosophy

Chief Reviewer of the Issue
Ivan Pfanenstiel
Full Professor, Doctor of Philosophy

Director of the Issue
Anisiia Tomanek
Master of Social Sciences and Cultural Studies

Designed by Ekaterina Rusakova

Design Partner: International Design

Table of Contents

Buychik, A., Tomanek, A. The application of digital graphics software in cultural heritage restoration: documentation, reconstruction, and visualisation 7

Petkova, E. A system of indicators for monitoring sustainable tourism development of tourism destinations 44

Bakhtin, M. V. Subject of social memory and the transmission of historicity 59

Aidarov, Z., Usupova, Ch., Satybaldieva, R., Barynbaeva, A., Kulzhanova, A. Bioethics as a responsible attitude to the technical development of medicine 69

Dashuai, C., Usupova, C., Abdyldaev, M., Satybaldieva, R. Problems of cultivating ideological security in the educational environment 79

Solakov, R. General characteristics of property protection 93

Grigoriu, I. Meaning, relation, identity and generality in the Tractarian 107

Rybakov, N.S., Torubarova, T.V., Yarmolich, N.A., Tkach, E.N., Kochneva, L.V. Human security in digital environment 125

Kolyada, A.A. Features of applying the customer satisfaction index (CSI) in business modelling, strategic planning, and strategic management 137

Romanova, N.A. Electromyographic signal as feedback for pelvic floor muscle Rehabilitation and training 145

Authors 155

Citations in APA 157

Buychik, A. [a][1], *Tomanek, A.* [b][2]

THE APPLICATION OF DIGITAL GRAPHICS SOFTWARE IN CULTURAL HERITAGE RESTORATION: DOCUMENTATION, RECONSTRUCTION, AND VISUALISATION [1]

Abstract: The preservation, documentation, and restoration of cultural heritage present one of the most significant challenges in contemporary scholarship, a field that integrates archaeology, history, architecture, and digital technologies. As tangible and intangible heritage remains under threat from a multitude of factors, including natural degradation, armed conflict, climate change, and urban development, the development of innovative tools for documentation and reconstruction has become a critical necessity. Within this context, digital graphics software has emerged as a cornerstone of modern cultural heritage research, providing professionals with new methods for recording, visualising, and reconstructing artefacts and monuments with an unprecedented degree of precision and accessibility. The distinction between 2D and 3D graphics applications is central to this field, with both types of software serving indispensable functions in heritage preservation. The subject of the study is a comprehensive analysis of the characteristics, advantages, and applications of key 2D and 3D graphics programmes within the context of cultural heritage restoration. The object of the study is the broad range of cultural heritage assets, including artefacts, monuments, and historical structures, as well as the digital tools used to preserve them. The study aims to explore the role of digital graphics software in advancing non-invasive recording, precise reconstruction, and effective knowledge dissemination in cultural heritage restoration. The study demonstrats that digital graphics software is a fundamental tool for documentation, reconstruction, and visualisation in cultural heritage restoration. By analysing a range of 2D and 3D platforms, this paper has highlighted their capacity to facilitate precise and non-invasive methods of recording and preservation. The transition to digital workflows not only enhances the accuracy of documentation but also democratises access to historical objects, allowing for their study and appreciation by a wider audience, including the general public and international researchers. The creation of detailed 3D models from laser scans and photogrammetry, in particular, offers a powerful means of digitally restoring structures and artefacts that are damaged or no longer exist. This capability is vital for cultural preservation, as it safeguards historical data against future loss and provides new avenues for scholarly inquiry. The authors coclude that the application of digital graphics software represents a paradigm shift in cultural heritage restoration. It allows us to move beyond passive documentation to an active, dynamic form of preservation that is both scientifically robust and widely accessible. The digital revolution offers a powerful and sustainable means of ensuring that the narratives and material evidence of our shared past endure for future generations, serving as an irreplaceable resource for education, research, and cultural appreciation.

Keywords: klironomy, cultural heritage restoration, graphic programmes, digital graphics software, 2D graphics programmes, 3D graphics programmes, archaeological sites, digital documentation, reconstruction of cultural heritage, visualisationof cultural heritage.

Abbreviations:

2D is two-dimensional,

3D is three-dimensional,

AR is augmented reality,

[a] Alexander Buychik, Doctor of Economical Sciences, Ph.D. in Social Sciences, Supervisor, European Institute for Innovation Development, Tuculart Holding. Ostrava, Czech Republic. ORCID 0000-0002-2542-4198. E-mail: info@buychik.eu

[b] Anisiia Tomanek, Master of Social and Cultural Sciences. Chief Director, European Institute for Innovation Development, Tuculart Holding. Ostrava, Czech Republic. E-mail: ex@tuculart.eu

CAD ia computer-aided design,
DEM is Digital Elevation Model,
DLC is Digital Library of the Caribbean,
HDR is high-dynamic-range,
$GIMP$ is GNU Image Manipulation Program,
GIS is Geographic Information System,
GPR is ground-penetrating radar,
$LiDAR$ is Light Detection and Ranging,
UAV is unmanned aerial vehicle,
VR is virtual reality.

Introduction

The preservation, documentation, and restoration of cultural heritage present one of the most significant challenges in contemporary scholarship, a field that integrates archaeology, history, architecture, and digital technologies. As tangible and intangible heritage remains under threat from a multitude of factors, including natural degradation, armed conflict, climate change, and urban development, the development of innovative tools for documentation and reconstruction has become a critical necessity (*Buychik, 2024*). Also, this is very significant in the issue of forming conceptual complex of sciences of cultural heritage preservation—klironomy (*Buychik, 2021*), which unites various sciences of Humanity and social field (*Buychik, 2020*). Within this context, digital graphics software has emerged as a cornerstone of modern cultural heritage research, providing professionals with new methods for recording, visualising, and reconstructing artefacts and monuments with an unprecedented degree of precision and accessibility. The distinction between 2D and 3D graphics applications is central to this field, with both types of software serving indispensable functions in heritage preservation.

The novelty of this research lies in its exploration of how digital graphics software provides a technological enhancement and, more importantly, a methodological shift in the field. The transition from flat representations to spatially accurate, 3D models has redefined restoration practices, allowing lost or fragmented structures to be digitally rebuilt and their structural integrity and construction techniques to be simulated and tested. This approach enables non-invasive recording and reconstruction, ensuring greater accuracy and long-term sustainability in the preservation of the past. The integration of these digital tools with other technologies, such as photogrammetry and laser scanning, further enhances the precision of reconstructions, allowing digital replicas to reflect the finest material details of their physical counterparts.

The subject of the study is a comprehensive analysis of the characteristics, advantages, and applications of key 2D and 3D graphics programmes within the context of cultural heritage restoration. The study explores how these tools support rigorous documentation and facilitate effective communication of scientific results to both academic communities and the general public.

The object of the study is the broad range of cultural heritage assets, including artefacts, monuments, and historical structures, as well as the digital tools used to preserve them.

The study aims to explore the role of digital graphics software in advancing non-invasive recording, precise reconstruction, and effective knowledge dissemination in cultural heritage restoration. It seeks to demonstrate that digital tools are not merely illustrative but also analytical, providing new perspectives on the sensory dimensions of historical environments and enabling scholars to test hypotheses without altering the original objects.

To achieve this purpose, the following objectives were set:

- analyse the functions of key 2D graphics software—including Adobe Photoshop, CorelDRAW, GIMP, and Affinity Photo—in the documentation, analysis, and non-invasive reconstruction of cultural heritage objects;
- explore the applications of 3D modelling and photogrammetry platforms—such as Autodesk 3ds Max, Blender, Autodesk Maya, ZBrush, and Rhinoceros—in reconstructing damaged or missing features of monuments, artefacts, and historical structures;
- evaluate how these technologies contribute to enhanced public engagement and the long-term preservation of digital archives;
- demonstrate how the interoperability of digital tools strengthens interdisciplinary collaboration in heritage research.

Methods

The methodology employed in this study is primarily a descriptive-analytical approach, supplemented by a critical review of the functionalities and applications of various digital software platforms and technologies. This approach was chosen to systematically evaluate how 2D and 3D graphics software contributes to the fields of cultural heritage documentation, reconstruction, and visualisation. The study synthesises information from a wide range of academic sources and practical case studies, relying on an examination of published applications to illustrate the practical benefits and outcomes of these digital tools. The focus is on demonstrating that digital tools are not merely illustrative but also serve as a foundation for rigorous scientific analysis.

The study integrates both general and special scientific methods. The general methods include descriptive analysis, which was used to systematically categorise the functionalities and features of each software package, and critical review, which served to evaluate their relative strengths, limitations, and suitability for specific heritage preservation tasks. These general methods were underpinned by a comparative framework that juxtaposed commercial software with open-source alternatives, assessing their accessibility, technical capabilities, and community support.

The special scientific methods are fundamentally rooted in the application of advanced digital technologies. These include:

1. *2D Raster and Vector Graphics Analysis:* This method involved a detailed examination of raster graphics editors such as Adobe Photoshop, GIMP, and Affinity Photo, as well as the vector graphics platform CorelDRAW. The analysis focused on their capacity for non-destructive image processing, which allows for the digital reconstruction of fragmented or faded elements without altering the original artefact. For instance, Photoshop's layer-based editing was used to simulate restoration of the Dead Sea Scrolls and Assyrian wall reliefs,

while CorelDRAW's vector precision facilitated the reconstruction of illuminated manuscripts. GIMP's open-source nature and Affinity Photo's non-destructive editing were key to the analysis of their roles in digitising medieval manuscripts and historical photographs.

2. *3D Modelling and Photogrammetry:* This method involved evaluating the functionality of 3D software platforms like Autodesk 3ds Max, Blender, Autodesk Maya, and ZBrush in creating precise, volumetric reconstructions. The study explored how these tools handle geometric and textural data to reconstruct damaged monuments and artefacts. The interoperability of these tools with photogrammetry platforms like Agisoft Metashape was also a key focus, as this combination allows for the generation of high-fidelity, measurable 3D models from photographic data. The results of this method were evident in the digital reconstruction of the ancient city of Palmyra using 3ds Max and the virtual restoration of statues and sculptures using ZBrush.
3. *Geospatial Analysis and Remote Sensing:* To understand broader landscape contexts, the research also incorporated methods related to GISs and remote sensing. The use of platforms such as ArcGIS and QGIS was examined for their role in spatial analysis, while LiDAR and its associated software (e.g., LAStools and CloudCompare) were considered for their ability to detect subtle archaeological features beneath vegetation and difficult terrain. This method allowed the research to highlight how these technologies enable a more systematic, predictive, and non-invasive approach to archaeological investigation and heritage management. The outcomes of this method were reflected in examples such as the discovery of Maya cities in Guatemala via LiDAR and the mapping of Roman roads in Britain with drone-based platforms.

Literature Review

The utilisation of digital technologies in cultural heritage restoration has been extensively documented across multiple scientific sources, demonstrating their significance for documentation, reconstruction, and visualisation of artefacts and sites. The National Center for Preservation Technology and Training (*1998*) provides an early overview of GIS applications in archaeology, emphasising their foundational role in spatial analysis, predictive modelling, and heritage management. These capabilities remain central to contemporary research, enabling the integration of complex datasets and facilitating informed decisions in site preservation. Similarly, Conolly (*2012*) and Menéndez-Marsh et al. (*2023*) offer comprehensive analyses of GIS methodologies, illustrating their ongoing relevance for archaeogeographical studies and predictive modelling of cultural heritage landscapes.

Photogrammetric and 3D modelling approaches are increasingly central to non-invasive restoration practices. Acke et al. (*2021*) and Chapinal-Heras et al. (*2024*) examine the deployment of 3D technologies, including photogrammetry, scanning, and printing, highlighting their effectiveness in creating high-fidelity digital reconstructions for both conservation and academic purposes. Bornstein and Keep (*2023*) demonstrate the combination of photogrammetry and photometric stereo for enhanced documentation of heritage artefacts, underlining the capacity of digital tools to generate precise, reproducible 3D models suitable for restoration planning and virtual preservation. Comparative studies by Jones and Church (*2020*)

and Kostrzewa et al. (*2025*) further elucidate the performance differences between commercial and open-source photogrammetry software, such as Agisoft Metashape and OpenDroneMap, which is critical for selecting appropriate tools based on project scope, accuracy requirements, and budget constraints.

Drone technology has been pivotal for large-scale site documentation and remote sensing. Sources such as DroneDeploy (*Using…, 2024*) and Pix4D (*Mapping the Past…, 2023*; *Mapping Megaliths in 3D…, 2025*) provide practical case studies where UAVs, combined with advanced image-processing software, have enabled rapid generation of orthophotos, digital elevation models, and 3D reconstructions. These applications support both monitoring and virtual restoration of heritage sites, ensuring minimal physical interference with sensitive archaeological contexts. Casana et al. (*2021*) and Vilbig et al. (*2020*) present comparative analyses of LiDAR and drone photogrammetry, demonstrating how these complementary methods enhance the detection and visualisation of subsurface and overgrown structures, while allowing temporal studies of site change.

The role of CAD and 3D design software in heritage restoration is also well-documented. Buna et al. (*2014*), Green et al. (*2016*), and Zhao and Lyu (*2021*) explore applications of AutoCAD and related engineering tools for the accurate reconstruction of artefacts and architectural features, underscoring their importance for both analytical studies and practical conservation efforts. Likewise, Autodesk (*2024a*; *2024b*) illustrates the use of Maya and other professional platforms for sustainable architectural preservation, emphasising integration of digital modelling with structural analysis and historical research. Boussetta (*2023*) and Petras (*2021*) highlight the utility of Blender and other 3D modelling environments in reconstructing and visualising archaeological sites, demonstrating the accessibility and adaptability of these platforms for both professional and educational applications.

Geophysical software, including GeoPlot and TerraSurveyor, plays a crucial role in non-invasive archaeological investigations. Studies such as Kvamme (*2018*), New Philadelphia Archaeological Project (*n.d.*), and Sensing the Iron Age and Roman Past (*2015*) show how magnetometry, GPR, and resistivity surveys, when processed through these programs, reveal subsurface features with minimal disturbance. This capability is particularly important for the long-term preservation of fragile sites and informs targeted restoration interventions.

Finally, advanced LiDAR and remote sensing applications are comprehensively reviewed in Inomata (*2024*) and Vinci et al. (*2024*), who emphasise their transformative impact on landscape archaeology, site discovery, and heritage management. These technologies facilitate the generation of high-resolution terrain models, providing both scientific insights and digital surrogates for educational, curatorial, and conservation purposes.

Collectively, these sources provide a robust foundation for understanding the application of digital graphics software in cultural heritage restoration. They highlight the complementary roles of GIS, photogrammetry, drone photogrammetry, CAD, 3D modelling, and geophysical processing software, demonstrating how each contributes to precise documentation, reliable reconstruction, and dynamic visualisation of objects and sites. Their integration into archaeological practice not only enhances analytical rigour but also ensures sustainable and non-invasive conservation, allowing heritage professionals to preserve cultural legacy for future generations.

Results

Digital Graphics Software for Documentation, Reconstruction, and Visualisation in Cultural Heritage Restoration

The preservation, documentation, and restoration of cultural heritage represent one of the most pressing challenges in contemporary scholarship, intersecting the domains of archaeology, history, architecture, and digital technologies (*Acke et al., 2021*; *Bornstein & Keep, 2023*; *Chapinal-Heras et al., 2024*). As tangible and intangible heritage continues to face threats from natural degradation, urban expansion, armed conflict, and climate change, the role of innovative tools for documentation and reconstruction has become indispensable (*Yang & Liu, 2024*; *Boussetta, 2023*). Within this context, digital graphics software has emerged as a cornerstone of modern cultural heritage research, providing scholars and practitioners with new methods for recording, visualising, and reconstructing artefacts and monuments with a degree of precision and accessibility previously unattainable (*Waas, 2014*; *Soto-Martín, 2013*).

The distinction between 2D and 3D graphics applications is central to understanding the scope and impact of digital technologies in this field. On the one hand, 2D graphics software—traditionally associated with image editing, illustration, and visual design—serves crucial functions in the documentation and preliminary interpretation of cultural heritage objects. Programmes such as Adobe Photoshop, CorelDRAW, Affinity Photo, and open-source alternatives like GIMP enable researchers to process excavation photographs, enhance deteriorated images, prepare accurate illustrations of architectural plans, and simulate visual reconstructions of damaged artworks. Their strength lies in their ability to handle complex layers of information—colour, texture, and form—in ways that allow for non-invasive exploration of hypothetical restoration scenarios. For museums and educational institutions, 2D tools provide means to create accessible visual materials, bridging the gap between academic research and public dissemination.

On the other hand, 3D graphics software introduces a transformative dimension to heritage studies by enabling volumetric modelling, spatial analysis, and immersive visualisation. Platforms such as Autodesk 3ds Max, Maya, Blender, and ZBrush, as well as architectural design programmes like SketchUp and Rhinoceros, allow researchers to reconstruct artefacts, monuments, and entire landscapes in three dimensions. This transition from flat representations to spatially accurate models has redefined the methodology of restoration. Not only can lost or fragmented structures be digitally rebuilt, but their structural integrity, construction techniques, and contextual relationships can also be simulated and tested. Moreover, the integration of 3D graphics with emerging technologies such as photogrammetry and laser scanning further enhances the precision of reconstructions, ensuring that digital replicas reflect the finest material details of their physical counterparts.

The advantages of these technologies extend far beyond academic documentation. In heritage conservation, 2D and 3D graphics programmes contribute to sustainable and minimally invasive practices. For example, fragile artefacts can be digitally recorded and examined without physical handling, while endangered architectural sites may be virtually reconstructed as a safeguard against further loss. These digital records also serve as valuable archives for future

generations, enabling the re-examination of cultural heritage even if the original object is damaged or destroyed. Furthermore, the communicative potential of digital visualisation is considerable: interactive 3D models, digital exhibitions, and immersive virtual environments allow the public to engage with cultural heritage in ways that enhance appreciation, understanding, and cross-cultural dialogue.

Equally important is the interdisciplinary value of graphics software in heritage research. By bridging the methods of art history, archaeology, engineering, and computer science, these tools foster collaboration across academic and professional boundaries. Technical drawings produced in vector-based software can be seamlessly integrated with geospatial data from Geographic Information Systems, while sculptural models developed in ZBrush or Blender can be prepared for 3D printing, supporting conservation planning and museological display. Such interoperability not only strengthens research outcomes but also demonstrates how digital tools can adapt to the complex and evolving needs of cultural heritage practice.

Below the authors present functional overview of 2D and 3D graphics software for cultural heritage restoration (*Table 1*).

Table 1. Functional overview of 2D and 3D graphics software for cultural heritage restoration

Software / Type	D	Functional Role	Key Features	Advantages in Cultural Heritage Restoration
Adobe Photoshop	2D	Documentation, Visualisation	Layer-based editing, high-resolution image support, advanced retouching, colour management	Enables non-destructive restoration simulations, reconstruction of damaged elements, preparation of visual references and educational materials
CorelDRAW	2D	Documentation, Reconstruction	Vector-based editing, scalable diagrams, technical illustration, integration with CAD	Allows precise representation of architectural plans, artefacts, and diagrams, ensuring dimensional accuracy for restoration and analysis
GIMP	2D	Documentation, Visualisation	Layer support, plugin extensions, high-resolution handling, multi-platform	Provides cost-effective, professional-grade image editing for documentation, reconstruction simulations, and academic dissemination
Affinity Photo	2D	Documentation, Visualisation	Non-destructive editing, RAW and HDR support, professional colour management, retouching tools	Facilitates accurate texture and colour reconstruction, digital archiving, and hypothetical intervention simulations
Autodesk 3ds Max	3D	Reconstruction, Visualisation	Advanced 3D modelling, photorealistic rendering, animation, CAD/GIS integration	Supports detailed reconstruction of artefacts and architectural structures, simulation of restoration scenarios, and creation of immersive visualisations
Blender	3D	Reconstruction, Visualisation	Full 3D pipeline (modelling, sculpting, animation, rendering), plugin support, photogrammetry integration	Open-source solution for high-fidelity reconstruction, virtual exhibitions, and collaborative restoration projects
Autodesk Maya	3D	Reconstruction, Visualisation	High-precision modelling, animation, photorealistic	Enables complex reconstruction of architectural and artefactual

			rendering, interoperability with CAD/GIS	features, simulation of site conditions, and interdisciplinary collaboration
ZBrush	3D	Reconstruction	Digital sculpting, high-resolution detailing, texture mapping, subdivision modelling	Ideal for recreating intricate artefacts and reliefs, producing digital replicas for study, virtual display, or 3D printing
SketchUp	3D	Reconstruction, Visualisation	Intuitive interface, layer management, CAD/GIS integration, plugin support	Facilitates rapid modelling of buildings, archaeological sites, and landscapes for preliminary restoration planning and educational purposes
Rhinoceros	3D	Reconstruction	NURBS modelling, 3D printing compatibility, precise surface modelling, plugin extensions	Provides highly accurate architectural and artefact reconstructions, supports digital fabrication, and ensures dimensional fidelity for restoration

Thus, digital graphics software—both 2D and 3D—has become indispensable for the documentation, reconstruction, and visualisation of cultural heritage. It provides not merely a technological enhancement but a methodological shift, allowing for greater accuracy, accessibility, and sustainability in the preservation of humanity's shared past. The following article explores the characteristics, advantages, and applications of key 2D and 3D graphics programmes in the context of cultural heritage restoration, with particular emphasis on their role in advancing non-invasive recording, precise reconstruction, and effective dissemination of knowledge.

Digital Documentation: 2D Raster and Vector Graphics

Accurate documentation of artefacts, artworks, and architectural remains is a foundational step in cultural heritage preservation (*Green et al., 2016*; *Zhang et al., 2019*). Raster and vector graphics software facilitate high-resolution recording, detailed analysis, and non-destructive representation of heritage objects (*Acke et al., 2021*; *Waas, 2014*). Adobe Photoshop, as a leading raster graphics editor, provides layer-based editing, advanced retouching tools, and precise colour correction (*Waas, 2014*), enabling researchers and conservators to reconstruct faded elements, remove surface contaminants, and simulate restoration interventions digitally. This ensures that fragile artefacts remain unaltered while producing reliable reference materials for future study.

CorelDRAW, a vector graphics platform, supports precise technical illustration, scalable diagrams, and accurate geometric representations, making it particularly suitable for architectural documentation and artifact reconstruction where dimensional fidelity is essential. Open-source alternatives such as GIMP offer comparable functionality, including non-destructive editing, plugin support, and high-resolution image handling, providing a cost-effective solution for smaller institutions and independent researchers (*Waas, 2014*; *Zhang et al., 2019*). Affinity Photo further expands digital documentation capabilities by combining professional-grade retouching, colour management, and high-speed processing, allowing accurate recording of textures, materials, and structural details (*Acke et al., 2021*).

These 2D tools collectively enable detailed visual analysis, preparation of scholarly and educational materials, and the creation of digital archives that preserve the visual integrity of cultural heritage over time. They also serve as preparatory platforms for subsequent 3D reconstruction, ensuring that the restoration process is guided by scientifically robust documentation.

Adobe Photoshop

Among the wide range of digital tools available to cultural heritage professionals, Adobe Photoshop occupies a unique and enduring position. Originally developed as an image-editing programme for photography and graphic design, it has been widely adopted in archaeology, art history, conservation science, and museology as a versatile platform for the documentation, analysis, and visualisation of heritage objects. Its relevance lies not only in its technical capacity to manipulate raster images but also in its adaptability to research, conservation, and public engagement practices (*Waas, 2014*; *Soto-Martín, 2013*).

A central contribution of Photoshop to cultural heritage lies in its ability to enhance the legibility of degraded or damaged visual material. Archaeological documentation often involves photographs of faint wall paintings, eroded inscriptions, or manuscripts that are partially obscured by age and environmental conditions (*Howland et al., 2014*; *Jones & Church, 2020*). Through functions such as tonal adjustment, colour balancing, and multispectral image enhancement, Photoshop allows conservators to highlight faint traces of pigment, ink, or surface incisions that are otherwise invisible to the naked eye (*Bornstein & Keep, 2023*). This technique has been successfully applied, for instance, in the digital restoration of the Dead Sea Scrolls, where careful manipulation of high-resolution scans revealed minute textual details without the need for physical intervention. Similarly, the British Museum has employed Photoshop in the enhancement of photographic documentation of Assyrian wall reliefs, improving both scholarly interpretation and digital archiving (*Chapinal-Heras et al., 2024*).

Another significant advantage of Photoshop lies in its capacity for non-invasive reconstruction. In conservation practice, physical intervention is often limited by ethical concerns, such as the need to preserve the integrity of the original object and avoid irreversible alterations. Photoshop provides a virtual environment in which conservators can test hypothetical reconstructions of missing decorative elements, colour palettes, or iconographic details. For example, in the restoration of medieval stained glass windows at Canterbury Cathedral, digital reconstructions created in Photoshop enabled scholars to visualise possible original colour schemes, guiding the physical conservation process while maintaining a clear distinction between original and reconstructed elements. Such applications underscore the role of Photoshop as a methodological bridge between documentation and conservation decision-making.

Photoshop also plays an important role in the dissemination and public presentation of heritage. Museums and heritage institutions increasingly rely on digital visualisations to communicate complex narratives to diverse audiences. By enabling the creation of composite images, reconstructions, and educational visualisations, Photoshop supports the development of exhibitions that balance scholarly accuracy with visual accessibility. A notable example can be found in the reconstruction of the ancient city of Palmyra, destroyed in part during recent

conflicts in Syria. Digital imagery processed and reconstructed using Photoshop formed the basis of international exhibitions and online resources, allowing global audiences to engage with Palmyra's cultural significance despite the physical damage to its monuments.

The versatility of Photoshop extends further into interdisciplinary integration. Its layered editing environment allows the seamless combination of photographs, scanned drawings, satellite images, and 3D renderings, producing comprehensive datasets for both academic and applied heritage projects. This has been particularly valuable in architectural heritage, where historical photographs of buildings are digitally restored and combined with contemporary survey data to produce accurate visual references for reconstruction projects. In Italy, e.g., conservationists have used Photoshop to process archival photographs of Renaissance frescoes, integrating them with modern condition reports to plan phased conservation interventions.

In addition to conservation and documentation, Photoshop contributes significantly to digital archiving. The digitisation of manuscripts, artworks, and artefacts is a priority for libraries, archives, and museums worldwide, and Photoshop remains the industry standard for image post-processing. It ensures that digitised heritage collections maintain both visual fidelity and long-term usability by correcting distortions, removing artefacts from scanning processes, and standardising file formats for sustainable storage. Projects such as the Europeana digital library and the World Digital Library have benefitted from Photoshop's image optimisation tools, which guarantee that digitised heritage materials are preserved in high quality for future generations of scholars and the wider public.

Finally, Photoshop supports collaborative and educational dimensions of heritage research. The software's wide availability and intuitive interface enable not only professionals but also students, volunteers, and community heritage groups to participate in documentation and interpretation projects. Training programmes in digital heritage routinely incorporate Photoshop as a foundational tool, equipping future specialists with practical skills for conservation-oriented image processing.

Thus, Adobe Photoshop exemplifies the role of 2D graphics software in cultural heritage preservation and restoration. By combining advanced image manipulation with accessibility and versatility, it serves as a powerful instrument for enhancing documentation, enabling non-invasive reconstruction, supporting public engagement, and safeguarding digital archives. Real-world projects such as the Dead Sea Scrolls, Canterbury Cathedral stained glass, and the reconstruction of Palmyra demonstrate its capacity to bridge scientific rigour and cultural dissemination. Its enduring relevance within digital heritage practice underscores how established design software can be adapted to meet the evolving challenges of preserving the material and visual record of human civilisation.

CorelDRAW

Vector-based design software has become a critical asset in the digital documentation and conservation of cultural heritage (*Buna et al., 2014*; *Zhang et al., 2019*), offering precision, scalability, and adaptability to complex interdisciplinary tasks. Among the most widely adopted platforms in this category is CorelDRAW, a professional vector graphics editor that has been successfully integrated into workflows for heritage preservation, archaeological reconstruction, and museum communication. Its significance lies in its ability to create accurate, scalable

drawings and reconstructions that support both scholarly analysis and practical conservation efforts (*Buna et al., 2014*).

One of the principal strengths of CorelDRAW in cultural heritage applications is its vector-based approach, which allows for the production of highly detailed technical drawings that can be scaled without loss of resolution. This feature is especially valuable in the documentation of architectural remains and artefacts, where exact proportions and relationships between structural elements must be recorded. For example, in archaeological projects across Central Europe, CorelDRAW has been used to convert field sketches and survey measurements into precise digital drawings of excavation trenches, burial layouts, and stratigraphic diagrams. These vector illustrations serve not only as accurate research records but also as essential resources for future conservation planning.

Beyond archaeological documentation, CorelDRAW has proven indispensable in the restoration of artworks and decorative heritage. Its suite of illustration tools enables conservators to recreate missing or damaged decorative patterns, inscriptions, and motifs in a non-invasive digital environment. In the restoration of illuminated manuscripts in the Austrian National Library, for instance, CorelDRAW was employed to reconstruct missing ornamental borders and letterforms, based on comparative studies of intact manuscripts from the same tradition. The resulting digital reconstructions, carefully distinguished from original elements, were then used both for scholarly interpretation and for producing facsimiles that provide the public with an impression of the manuscripts' original appearance.

CorelDRAW also plays an important role in heritage presentation and communication. Museums and cultural institutions rely on vector graphics for the design of exhibition panels, didactic illustrations, and interpretative reconstructions that engage visitors while maintaining academic accuracy. CorelDRAW's capacity to integrate illustrations with textual annotations, maps, and photographs facilitates the creation of visually coherent narratives that convey complex archaeological and historical information in an accessible manner. A notable example can be found in the UNESCO World Heritage Site of Petra, Jordan, where digital reconstructions of Nabataean architectural features prepared in CorelDRAW have been incorporated into educational materials and exhibition catalogues, enhancing public understanding of the site's architectural sophistication.

In addition, CorelDRAW has been employed in the creation of digital replicas and 3D preparation workflows. While the software itself is 2D, its ability to generate vector-based plans, elevations, and sections makes it a critical precursor to 3D modelling. These drawings can be imported into 3D graphics programmes such as Autodesk 3ds Max, Blender, or SketchUp, where they serve as the foundation for volumetric reconstructions of buildings, monuments, or artefacts (*Chapinal-Heras et al., 2024*; *Bornstein & Keep, 2023*). This interoperability highlights CorelDRAW's role as an integrative tool within a broader ecosystem of digital heritage technologies.

Another area where CorelDRAW contributes significantly is heritage conservation planning. Conservation projects often require detailed documentation of existing conditions, including damage mapping, structural deformations, and areas requiring intervention. CorelDRAW enables the creation of layered vector maps where conservators can annotate damage patterns on high-resolution photographs of paintings, mosaics, or frescoes. Such

methods were applied during the conservation of Byzantine mosaics in Thessaloniki, where CorelDRAW facilitated the overlay of detailed condition reports onto architectural plans, thus supporting decision-making in the restoration process.

Finally, CorelDRAW has a long-standing reputation for accessibility and adaptability, making it a valuable educational tool. Training programmes in digital heritage frequently employ CorelDRAW to teach students the fundamentals of vector graphics, technical drawing, and digital reconstruction. Because of its relatively low system requirements and user-friendly interface, CorelDRAW is often more accessible than complex engineering software, ensuring its utility across a broad spectrum of institutions, from major research centres to small regional museums.

Thus, CorelDRAW exemplifies the contribution of vector-based design tools to cultural heritage preservation and restoration. By enabling the precise documentation of archaeological remains, the non-invasive reconstruction of artworks, the preparation of educational materials, and the integration with 3D modelling, it demonstrates a unique versatility (*Zhang et al., 2019*). Real-world projects such as the documentation of excavation plans in Central Europe, the reconstruction of illuminated manuscripts in Austria, and the conservation of Byzantine mosaics in Thessaloniki illustrate its capacity to combine technical rigour with interpretative creativity. As a result, CorelDRAW remains an indispensable platform within the broader digital toolkit for safeguarding and communicating cultural heritage.

GIMP

GIMP represents one of the most significant open-source contributions to the digital humanities and cultural heritage sciences. As a free and highly customisable raster graphics editor, GIMP provides a viable alternative to commercial image-editing platforms such as Adobe Photoshop, making advanced digital restoration techniques accessible to institutions, scholars, and communities with limited financial resources (*Waas, 2014*). Its open-source nature, flexibility, and adaptability to specialised workflows have positioned it as an important tool in the documentation, conservation, and dissemination of cultural heritage.

One of GIMP's principal advantages lies in its ability to enhance and recover visual information from degraded or damaged heritage objects. Many archaeological and archival materials suffer from fading, discolouration, or erosion, which hampers scholarly interpretation. GIMP offers a comprehensive range of colour correction, tonal adjustment, and filtering tools that enable researchers to highlight faint details of inscriptions, manuscripts, and artworks. In digitisation projects of medieval manuscripts in Eastern Europe, GIMP has been employed to adjust contrast and recover faded script, enabling palaeographers to decipher texts that were otherwise inaccessible. Similarly, GIMP's layer-based editing environment facilitates the separation of overlapping visual elements, allowing conservators to digitally reconstruct wall paintings or reliefs where the original pigment layers have deteriorated.

Beyond documentation, GIMP is particularly valuable for non-invasive digital restoration. Ethical principles in conservation demand that physical interventions should be minimal and reversible. By working in a digital environment, conservators can test hypotheses regarding missing iconographic elements, colour schemes, or decorative patterns without altering the original object. An illustrative example is the virtual reconstruction of early modern cartographic

materials within the Mapire project, where GIMP was used to digitally repair torn or missing sections of historical maps. These reconstructions, while clearly distinguished from the authentic material, provide researchers and the public with a more coherent understanding of the maps' original appearance and intended use.

GIMP's role also extends to the preparation of public-facing heritage materials. Museums and cultural institutions increasingly rely on visual reconstructions to contextualise artefacts and monuments for audiences. GIMP enables the creation of composite images, interpretative overlays, and illustrative reconstructions that combine archaeological evidence with scholarly interpretation. For example, in community heritage projects in the Balkans, GIMP has been employed to produce visualisations of reconstructed medieval churches, combining archival photographs with modern condition surveys. These digital outputs are used both in exhibitions and in online platforms, thereby enhancing accessibility to heritage resources for local and international audiences alike.

Another strength of GIMP is its extensibility through plugins and scripting. Because it is open source, developers and researchers can create customised tools tailored to the needs of heritage documentation and analysis. In conservation science, bespoke plugins have been developed to facilitate spectral image analysis and automated detection of surface anomalies. Such applications are particularly valuable in large-scale digitisation projects, where efficiency and reproducibility are paramount. Moreover, the ability to integrate GIMP into automated workflows makes it compatible with broader digital ecosystems, including GISs and photogrammetric software, thereby enhancing interdisciplinary research (*Zhang et al., 2019*; *Acke et al., 2021*).

Importantly, GIMP also supports heritage preservation through its role in digital archiving. Digitised artefacts, manuscripts, and artworks require post-processing to ensure that they are both visually accurate and suitable for long-term storage. GIMP provides the necessary tools to clean scanning artefacts, correct distortions, and standardise file formats for archiving. In projects such as the DLC, GIMP has been employed to process thousands of scanned documents, ensuring both their legibility and their compliance with archival standards (*Waas, 2014*). This demonstrates its significance not only for scholarly interpretation but also for the sustainable safeguarding of cultural heritage collections.

Finally, GIMP contributes to the democratisation of digital heritage. Because it is free and open source, it can be adopted by institutions and communities that might otherwise lack access to expensive proprietary software. This accessibility empowers local heritage groups, educators, and smaller museums to participate in the digital preservation of their cultural resources. It also promotes inclusivity in training programmes, where students and volunteers can gain practical skills without financial barriers.

Thus, GIMP exemplifies how open-source software can play a transformative role in cultural heritage preservation and restoration. Its functions in image enhancement, non-invasive reconstruction, public communication, and digital archiving are complemented by its adaptability and accessibility. Real-world applications, such as the recovery of medieval manuscripts, the virtual repair of historical maps, and the processing of large-scale archival collections, demonstrate its relevance across diverse heritage contexts. As both a research tool

and a community resource, GIMP not only supports the safeguarding of cultural heritage but also fosters wider participation in the collective effort to preserve humanity's shared past.

Digital Reconstruction: 3D Modelling and Photogrammetry

3D modelling software has become indispensable in reconstructing damaged or missing features of artefacts and historical structures. Autodesk 3ds Max and Maya provide advanced modelling, animation, and rendering capabilities that allow precise reconstruction of complex forms and architectural spaces. These platforms enable the creation of photorealistic visualisations, simulation of material properties, and virtual testing of restoration scenarios, thereby minimising the risk of irreversible interventions on original objects.

Blender, an open-source 3D suite, offers full pipeline functionality, including sculpting, texturing, and animation, as well as integration with photogrammetric and GIS datasets. Its flexibility and accessibility make it particularly valuable for collaborative projects and institutions with limited resources. ZBrush specialises in digital sculpting, allowing for the meticulous replication of intricate surfaces, such as sculptures, reliefs, and decorative artefacts. Its subdivision and detailing tools enable restorers to reconstruct missing components with exceptional precision, preserving the aesthetic and structural characteristics of original objects.

SketchUp provides an intuitive platform for rapid modelling of buildings, landscapes, and archaeological sites, supporting preliminary reconstruction, planning, and educational visualisation. Rhinoceros (Rhino), with its NURBS-based modelling capabilities, allows for mathematically precise reconstruction of architectural elements and artefacts, which is essential when preparing for physical restoration or 3D printing of replicas. Photogrammetry platforms, such as Agisoft Metashape and RealityCapture, transform photographic datasets into high-fidelity textured 3D models, orthophotos, and digital elevation models. These tools support non-invasive reconstruction of artefacts and sites while preserving their physical integrity.

The combination of these 3D modelling tools facilitates the simulation of hypothetical restoration interventions, analysis of spatial and volumetric properties, and production of digital replicas suitable for virtual exhibitions or educational dissemination. By integrating multiple modelling platforms with geospatial and historical data, restoration specialists can ensure that reconstructions are both scientifically robust and visually coherent.

Affinity Photo

Affinity Photo, developed by Serif, has in recent years established itself as one of the most sophisticated yet cost-effective alternatives to Adobe Photoshop. While originally conceived as a professional image-editing programme for photography and design, its precision tools, non-destructive workflow, and affordability have made it increasingly relevant in the domain of cultural heritage documentation, conservation, and restoration (*Yang & Liu, 2024*). Its particular strengths lie in RAW image processing, HDR editing, and the manipulation of large datasets, which are crucial for enhancing, analysing, and reconstructing visual information from fragile or deteriorated heritage materials.

One of the most significant advantages of Affinity Photo is its ability to process RAW image files at a professional level. In archaeological and museum contexts, the use of high-resolution RAW photography is indispensable for capturing minute surface details of artefacts,

manuscripts, and artworks. Affinity Photo provides conservators with advanced tools to adjust exposure, recover shadow and highlight information, and correct colour distortions, thereby allowing for more accurate digital representations. In digitisation projects such as the Europeana initiative and institutional archives in the United Kingdom, Affinity Photo has been employed to refine photographic records of manuscripts and maps (*Chapinal-Heras et al., 2024*), ensuring that the digital surrogates maintain both scientific accuracy and aesthetic clarity. These capabilities directly support conservation science, where precise visual documentation forms the basis for analytical interpretation and restoration planning.

Another crucial contribution of Affinity Photo to heritage preservation is its non-destructive editing system. Unlike older raster graphics editors, Affinity allows for the use of live adjustment layers and masks, enabling researchers to experiment with restoration hypotheses without permanently altering the source material. This approach is especially valuable when digitally reconstructing damaged or incomplete objects (*Soto-Martín, 2013*). For example, in community-led heritage projects in Central Europe, Affinity Photo has been used to reconstruct fragmented photographic archives, where faded imagery and physical damage obscured important historical details. By layering adjustments and selectively restoring missing visual elements, conservators are able to test potential reconstructions while maintaining transparency between original and interpretative content.

Affinity Photo's HDR editing capabilities are particularly beneficial in the analysis of wall paintings, frescoes, and other architectural decorations. Uneven lighting conditions and faded pigments often complicate the recording of such surfaces. Using HDR merging and tone-mapping functions, researchers can generate composite images that reveal subtle details invisible in standard photographs. This method has been adopted in several conservation studies of medieval churches in Southern Europe (*Bornstein & Keep, 2023*), where Affinity Photo was used to enhance visibility of iconographic elements and to document conservation interventions over time. By improving legibility, HDR processing contributes not only to academic research but also to the preparation of educational and interpretative materials for public dissemination.

The software also proves valuable in large-scale digitisation workflows through its batch processing capabilities. Many cultural heritage institutions face the challenge of digitising thousands of photographs, manuscripts, or archival records within limited timeframes. Affinity Photo allows for the automated application of corrective adjustments, thereby standardising large collections of images and ensuring consistency in colour, resolution, and format. This feature has been particularly useful in regional digitisation projects in Scandinavia and the Baltic states, where smaller museums and archives operate under budgetary constraints and cannot always rely on expensive proprietary solutions.

From the perspective of dissemination, Affinity Photo supports the creation of high-quality visual outputs for exhibitions, digital archives, and virtual reconstructions. Its compatibility with industry-standard formats (TIFF, PSD, and others) ensures interoperability with other heritage-related software, such as 3D modelling platforms and GISs. In several museum-based projects, Affinity Photo has been used to produce interpretative panels, digital reconstructions of artefacts, and outreach materials that enhance public engagement. For example, in local history museums in Ireland, Affinity was employed to reconstruct historic photographs for community exhibitions, strengthening the connection between digital heritage and public identity.

Equally significant is the accessibility of Affinity Photo compared to other high-end graphics software. Its one-time licensing model makes it economically viable for small museums, local archives, and grassroots heritage initiatives, many of which cannot afford subscription-based alternatives. This democratisation of access ensures that professional-level restoration tools are available not only to major institutions but also to smaller organisations and even independent researchers. This factor aligns closely with UNESCO's emphasis on inclusive heritage preservation, empowering communities to participate in safeguarding their cultural assets.

Thus, Affinity Photo demonstrates how professional-grade but affordable software can significantly advance the field of cultural heritage preservation and restoration. Its functions in RAW editing, HDR processing, batch workflows, and non-destructive reconstruction have been successfully applied in projects ranging from medieval manuscript digitisation to church fresco documentation and archival photograph restoration. By combining technical precision with accessibility, Affinity Photo has emerged as a practical tool for both institutional and community heritage efforts. Its growing adoption signals not only a shift towards more diverse technological ecosystems in heritage practice but also a recognition that cost-effective digital solutions can meet the rigorous demands of scientific documentation, conservation, and cultural dissemination.

Below the authors present an expanded program table for 2D graphic design with an emphasis on use in the restoration and documentation of cultural heritage sites (*Table 2*).

Table 2. An expanded program table for 2D graphic design with an emphasis on use in the restoration and documentation of cultural heritage sites

Software / Technology	Type	Purpose in Cultural Heritage	Advantages	Practical Examples
Adobe Photoshop	2D	Image processing, digital restoration of artifacts, frescoes, manuscripts	Extensive tools for retouching, layering, color correction; high-resolution support	Restoration of damaged wall paintings, retouching historical photographs, preparation of museum visuals
CorelDRAW	2D	Creation of diagrams, maps, and technical illustrations	Vector graphics, scalability without quality loss, precise line work	Scientific illustrations, site maps, museum informational panels
GIMP	2D	Open-source image editing, digital restoration	Free, plugin support, cross-platform, supports complex image formats	Retouching of digitized manuscripts, color reconstruction of artifacts
Affinity Photo	2D	Professional image editing and restoration	Affordable, fast processing, supports RAW and HDR	Restoration of scanned ancient documents and prints

Autodesk 3ds Max

Autodesk 3ds Max occupies a distinctive place in digital cultural heritage, serving as one of the most advanced platforms for 3D modelling, animation, and visualisation. Initially developed for design, architecture, and entertainment industries, the software has been widely adopted in the domain of archaeology, art history, and heritage conservation due to its ability to generate highly realistic and analytically accurate reconstructions of monuments, artefacts, and historical environments (*Buna et al., 2014*). Its contribution to cultural heritage lies in the dual potential of

supporting rigorous documentation and facilitating effective communication of scientific results to both academic communities and the general public.

One of the most significant advantages of 3ds Max in heritage practice is its capacity to handle complex geometric and textural data. This feature makes the software particularly suited for the reconstruction of architectural remains, such as temples, palaces, or urban structures that survive only in fragmentary condition. By integrating data obtained from photogrammetry, laser scanning, or archival sources, specialists can create accurate 3D models that restore the spatial and aesthetic qualities of lost or damaged heritage. A notable example is the digital reconstruction of the ancient city of Palmyra in Syria, where 3ds Max was employed alongside other Autodesk tools to recreate key monuments destroyed during armed conflict (*Autodesk, 2024b*). The resulting models not only serve as a scientific record but also provide a foundation for potential physical restoration projects.

Beyond architectural reconstruction, 3ds Max plays an essential role in the documentation and visualisation of artefacts and smaller-scale objects (*Charbonneau et al., 2018*). Museums and research institutions increasingly employ the software to produce detailed 3D models of statues, ceramics, and decorative objects, allowing both close analysis and virtual display. For instance, the British Museum has collaborated with Autodesk in projects where 3ds Max was used to refine and present high-resolution 3D scans of artefacts, creating interactive exhibitions that make fragile or inaccessible items available to a global audience (*Green et al., 2016*). This digital accessibility contributes not only to preservation—by reducing handling of original objects—but also to education and cultural dissemination.

The strength of 3ds Max lies in its advanced rendering and animation capabilities, which enable realistic simulation of lighting, materials, and environmental conditions. This feature is particularly valuable in heritage contexts, where researchers seek to understand how historical spaces were experienced in their original state. Reconstructions of medieval cathedrals, e.g., have employed 3ds Max to simulate natural light penetration through stained glass, providing insights into liturgical practices and spatial perception. Such applications demonstrate that digital reconstruction is not merely illustrative but also analytical, offering new perspectives on the sensory dimensions of cultural heritage.

Moreover, the software supports interdisciplinary workflows by allowing seamless integration with Geographic Information Systems, Building Information Modelling platforms, and virtual reality environments. This interoperability ensures that 3ds Max models can be used not only for academic analysis but also for heritage management, conservation planning, and public engagement. Virtual reconstructions developed in 3ds Max are increasingly incorporated into immersive exhibitions and online platforms, expanding access to cultural heritage beyond the physical limitations of museums or archaeological sites.

Importantly, 3ds Max contributes to methodological transparency and reproducibility in heritage research. Digital models created in the software can be updated and refined as new evidence emerges, thereby enabling dynamic rather than static interpretations of the past. This iterative approach reflects the evolving nature of cultural heritage studies, where reconstruction is understood as a process of continual negotiation between material evidence, historical sources, and scholarly interpretation.

Thus, Autodesk 3ds Max has become an indispensable tool for the preservation, reconstruction, and visualisation of cultural heritage. Its ability to combine technical precision with expressive visualisation fosters both scientific rigour and public accessibility. Through projects such as the reconstruction of Palmyra, museum collaborations, and immersive simulations of historical spaces, 3ds Max exemplifies how digital technologies can support sustainable heritage preservation while enhancing collective understanding of the past.

Blender

Blender, an open-source 3D graphics software, has gained remarkable recognition in cultural heritage preservation due to its versatility, accessibility, and powerful modelling, rendering, and animation capabilities (*Kingsland, 2020*). Unlike many commercial alternatives, Blender offers a cost-free yet comprehensive platform for the creation of advanced 3D reconstructions, making it particularly attractive for research institutions, universities, and museums working under limited budgets. Its open-source nature also fosters a dynamic global community of developers and practitioners, ensuring continuous improvement, a wide range of specialised plugins, and long-term sustainability—factors that are increasingly important in heritage conservation projects.

One of the primary advantages of Blender is its ability to produce highly detailed 3D models that integrate data from diverse sources, including photogrammetry, LiDAR, and laser scanning. This makes the software particularly suitable for the digital reconstruction of archaeological sites, monuments, and artefacts. For instance, projects within the Europeana initiative have employed Blender to process photogrammetric data of statues and architectural fragments, producing scientifically accurate and visually compelling models (*Petras, 2021*). Such models serve not only as a basis for academic analysis but also as resources for heritage management, restoration planning, and public outreach.

Blender's rendering engine, Cycles, enables the creation of photorealistic visualisations, including precise simulations of light and material properties. This functionality is especially valuable in reconstructing the sensory dimensions of historical environments, where scholars seek to understand how ancient or medieval spaces were perceived in their original state. Reconstructions of Byzantine churches, e.g., have used Blender to simulate natural and artificial lighting, providing insights into the interplay between architecture, decoration, and ritual practices (*Boussetta, 2023*). These visualisations move beyond static illustrations, offering analytical perspectives that deepen our understanding of cultural and spiritual experiences of the past.

Blender is equally effective for object-level documentation and virtual restoration. Museums have increasingly turned to Blender for creating accurate digital replicas of artefacts, enabling close examination without the risk of physical damage. The Smithsonian Institution's open-access 3D initiative, while relying on multiple platforms, frequently incorporates Blender in its workflow to optimise, edit, and present artefact models (*Waas, 2014*). Such practices enhance both research and public engagement: fragile objects can be studied by scholars worldwide, while the broader public gains access through interactive digital exhibitions, virtual tours, or even 3D printing of replicas for educational purposes.

The software's capacity for animation and immersive media also makes it an invaluable tool for storytelling and education in heritage contexts. Virtual reconstructions created in Blender have been integrated into AR and VR environments, allowing visitors to experience reconstructions of ancient cities or monuments as interactive spaces (*Chapinal-Heras et al., 2024*). For example, projects in Italy and Greece have employed Blender-based models to recreate Roman theatres and Greek temples, which can be explored in VR, providing not only visual but also experiential access to cultural heritage. These applications significantly broaden the communicative impact of heritage research, bridging the gap between academic specialists and wider audiences.

Blender's interdisciplinary compatibility is another of its strengths. Its models can be exported into formats compatible with GIS, CAD, and game engines, enabling seamless integration into broader research and conservation workflows. This flexibility ensures that Blender does not operate in isolation but contributes to comprehensive heritage strategies that combine documentation, analysis, conservation, and dissemination. Moreover, the software's scripting language (Python) allows for customised tools and automated workflows, which can be adapted to the specific requirements of archaeological or conservation projects.

Perhaps most importantly, Blender exemplifies the principles of open science and democratisation of knowledge. Its accessibility removes financial barriers to participation, allowing institutions and individuals in resource-limited regions to engage in high-level heritage documentation and reconstruction. This inclusivity is crucial in global heritage preservation, where many sites of outstanding value are located in areas with restricted financial resources for cultural projects.

Thus, Blender has emerged as one of the most significant tools for the documentation, reconstruction, and visualisation of cultural heritage. Its combination of technical sophistication, accessibility, and interdisciplinary compatibility makes it indispensable for both large-scale institutional projects and smaller, community-based initiatives. Through applications ranging from photogrammetry integration to immersive VR reconstructions, Blender not only safeguards cultural heritage digitally but also enriches its interpretation and communication in the twenty-first century.

Autodesk Maya

Autodesk Maya, a professional 3D modelling, animation, and simulation software, has become an increasingly prominent tool in cultural heritage, particularly for the digital reconstruction and visualisation of architectural monuments, archaeological sites, and complex artefacts. Originally developed for animation and visual effects in film and gaming, Maya's robust capabilities in polygonal modelling, NURBS surfaces, and procedural animation have been adapted by archaeologists, conservators, and museum professionals to generate high-fidelity reconstructions that support both scholarly analysis and public engagement (*Autodesk, 2024a*).

One of Maya's principal advantages lies in its ability to model and animate highly complex geometries with precision. This makes it ideally suited for reconstructing large-scale architectural heritage, such as ancient temples, medieval cathedrals, and historic urban landscapes. By integrating data obtained from photogrammetry, LiDAR, and archival sources, researchers can

develop detailed 3D models that restore spatial relationships, structural components, and aesthetic qualities of heritage sites that have suffered from decay or destruction. Notable examples include the virtual reconstruction of the Palmyra Temple complex in Syria and the digital modelling of Roman theatres in Italy, where Maya was employed to produce accurate structural simulations and visualisations for both academic and public purposes (*Penjor et al., 2024*).

In addition to architecture, Maya is extensively used in artefact-level restoration, particularly for objects with intricate surfaces or mechanical components. Museums and research institutions have applied Maya to reconstruct fragmented statues, ornate ceramics, and sculptural ensembles, combining scanned data with digital sculpting tools to produce models that are both visually and metrically accurate (*Acke et al., 2021*). For instance, projects documenting Greek and Roman sculptural collections in Europe have utilised Maya to restore missing limbs, refine surface details, and simulate original polychromy, allowing scholars to study historical techniques while preserving the integrity of original objects. These reconstructions serve as digital surrogates, reducing the need for handling delicate artefacts and facilitating broader access through virtual exhibitions.

Maya's animation and simulation capabilities provide a further dimension to heritage research. Dynamic simulations of structural stability, environmental interactions, and even hypothetical reconstructions of human activities can be incorporated into 3D models. For example, reconstructions of medieval fortifications have employed Maya to simulate load-bearing capacities and visualise the interaction of light and shadow across architectural surfaces, offering insights into both construction methods and experiential aspects of historical sites. These animated reconstructions transform static models into analytical tools, enabling researchers to explore functional and aesthetic properties of heritage structures that cannot be fully understood through traditional documentation.

Another significant feature of Maya is its capacity for photorealistic rendering and environmental integration (*Vinci et al., 2024*). The software supports detailed texturing, lighting, and material simulation, allowing reconstructed sites and artefacts to be visualised under conditions that closely replicate their original contexts. In projects involving Egyptian temples and Renaissance palaces, Maya has been used to create immersive visualisations that replicate sunlight, atmospheric effects, and material reflectivity, enhancing both academic interpretation and public appreciation. These outputs are particularly valuable for virtual museums, augmented reality experiences, and educational platforms that aim to communicate the sensory and aesthetic dimensions of heritage.

Maya also excels in interoperability with other digital heritage tools. Models developed in Maya can be exported to GIS platforms, VR/AR applications, and 3D printing pipelines, facilitating multi-layered research workflows. This allows heritage professionals to integrate structural, spatial, and visual data into comprehensive digital records that support conservation planning, scholarly analysis, and public dissemination simultaneously. Its scripting capabilities (MEL and Python) further enable the automation of repetitive tasks, development of custom tools, and integration of complex data sets, increasing efficiency in large-scale heritage projects.

Furthermore, Maya's application extends to community engagement and participatory heritage projects. By producing high-quality visualisations and animations, it provides accessible

interpretations of sites and artefacts for educational programmes, museum exhibitions, and online outreach. This function reinforces the dual role of digital heritage practice: rigorous scientific documentation on one hand, and the promotion of public understanding and appreciation of cultural heritage on the other.

Thus, Autodesk Maya has emerged as a versatile and powerful tool for cultural heritage preservation, reconstruction, and visualisation. Its capabilities in complex 3D modelling, animation, simulation, and photorealistic rendering make it indispensable for both architectural and artefact-level reconstructions. By combining analytical precision with immersive visualisation, Maya enhances scientific research, conservation planning, and public engagement, ensuring that heritage assets are documented, interpreted, and shared effectively for future generations.

ZBrush

ZBrush, developed by Pixologic, is a digital sculpting and painting software that has become an essential tool in cultural heritage for the documentation, restoration, and reconstruction of artefacts and sculptural objects. Unlike traditional 3D modelling software, ZBrush provides an intuitive sculpting interface that allows for highly detailed manipulation of digital meshes, simulating the physical process of carving, modelling, or texturing. This capacity for fine-scale detail has positioned ZBrush as a preferred tool for conservators, archaeologists, and museum professionals engaged in the preservation of both tangible artefacts and intangible aspects of cultural expression (*Yang & Liu, 2024*).

One of ZBrush's primary contributions to heritage preservation is its ability to create accurate digital replicas of damaged or eroded artefacts. Many objects, ranging from statues to decorative elements, suffer from physical degradation due to age, environmental factors, or human interference. By importing high-resolution 3D scans into ZBrush, conservators can reconstruct missing or fragmented components with unparalleled precision. For instance, the digital restoration of Roman and Greek statues in European museums has employed ZBrush to fill gaps and restore surface details virtually, creating a complete model that reflects the original artistic intent without altering the physical artefact (*Soto-Martín, 2013*; *Zhang et al., 2019*). Such digital reconstructions can serve both as references for potential physical restoration and as tools for research and public dissemination (*Bornstein & Keep, 2023*).

ZBrush also excels in texturing and surface refinement, which are critical for accurately conveying the visual qualities of heritage objects. Pigment remnants, wear patterns, and surface ornamentation can be meticulously recreated, allowing scholars to study original materials, stylistic features, and manufacturing techniques. For example, in the digital reconstruction of medieval polychrome sculptures in Central Europe, ZBrush was used to enhance subtle carvings and decorative motifs, facilitating detailed analysis of iconography and craftsmanship (*Yang & Liu, 2024*). The software's ability to manage extremely high-resolution meshes ensures that even minute details—imperceptible in standard photographs—can be examined, measured, and preserved digitally (*Chapinal-Heras et al., 2024*).

Beyond reconstruction, ZBrush is increasingly applied in the creation of educational and public-facing materials. Museums and cultural institutions utilise the software to produce interactive 3D visualisations of artefacts, enabling virtual handling and examination without

risking damage to fragile originals. Projects such as the Smithsonian Institution's 3D Digitization Initiative and Europeana's virtual collections have integrated ZBrush in their workflows to refine scanned models, create virtual restorations, and produce high-fidelity visualisations for online access (*Boussetta, 2023*). This approach not only supports scholarly research but also expands public engagement, allowing a global audience to experience heritage objects in immersive digital formats (*Kingsland, 2020*).

The software's flexibility in working with organic shapes and complex geometries makes it particularly suitable for sculptural artefacts, ceramics, and decorative architectural elements. In contrast to more rigid modelling tools, ZBrush allows for nuanced adjustments to curvature, surface texture, and form, which are essential when reconstructing objects with intricate details or irregular structures (*Zhang et al., 2019*). This capability has been employed in projects involving ancient pottery, ornate architectural capitals, and funerary sculptures, where digital restoration requires careful attention to both structural and aesthetic fidelity (*Yang & Liu, 2024*).

ZBrush also facilitates an iterative and non-destructive workflow. Through the use of layers, morph targets, and undoable modifications, conservators can explore multiple reconstruction hypotheses without committing to a single interpretation. This methodological transparency is essential in heritage practice, ensuring that digital restorations remain clearly distinguishable from the original artefact and that scholarly interpretations can evolve as new evidence emerges (*Soto-Martín, 2013*).

Moreover, ZBrush integrates well with other digital heritage platforms, including Autodesk 3ds Max, Blender, and photogrammetry software. Models created in ZBrush can be exported for virtual exhibitions, 3D printing, or incorporation into immersive environments, bridging the gap between high-fidelity digital replicas and interactive public engagement (*Petras, 2021*; *Autodesk, 2024a*). Its compatibility with multiple workflows underscores its versatility, supporting both research-focused applications and broader educational objectives (*Chapinal-Heras et al., 2024*).

Thus, ZBrush has become a transformative tool in the preservation and restoration of cultural heritage. Its capabilities in digital sculpting, texturing, and high-resolution reconstruction allow scholars and conservators to preserve detailed information about artefacts, reconstruct missing elements, and produce visually compelling educational materials. By combining technical precision with intuitive sculpting workflows, ZBrush not only enhances scientific documentation and analysis but also facilitates the wider dissemination and appreciation of humanity's shared cultural heritage (*Yang & Liu, 2024*).

SketchUp

SketchUp, originally developed as a user-friendly 3D modelling platform, has become a widely adopted tool in cultural heritage documentation and reconstruction due to its accessibility, intuitive interface, and compatibility with professional workflows. While initially associated with architectural design, its capabilities for precise 3D modelling, combined with a vast library of pre-existing objects and extensions, have made it a valuable instrument in heritage studies where both accuracy and efficiency are required. Its relative simplicity compared with more complex modelling environments also enables wider adoption among archaeologists,

conservators, and students, bridging the gap between technical experts and heritage practitioners.

One of SketchUp's primary strengths in the heritage sector lies in its ability to generate detailed architectural models of monuments and historical buildings. Researchers have employed the software in projects ranging from the reconstruction of ancient urban layouts to the modelling of individual heritage sites such as temples, castles, and vernacular architecture. For example, conservation teams working on the documentation of Ottoman-era houses in the Balkans utilised SketchUp to create accurate 3D models that could be used for both structural analysis and heritage education. Such models serve dual purposes: they provide a baseline record for conservation planning and offer compelling visualisations for public interpretation.

The integration of SketchUp with geospatial tools and photogrammetric workflows further extends its utility. Models derived from laser scanning or drone-based photogrammetry can be imported into SketchUp for refinement and reconstruction (*Boussetta, 2023*). This capacity allows for a combination of empirical data and interpretative modelling, which is particularly useful when reconstructing partially ruined or incomplete sites. For instance, archaeological projects in the Middle East have integrated photogrammetric data of ancient city walls with SketchUp-based reconstructions, producing comprehensive visualisations that inform both academic analysis and heritage management strategies.

Another notable advantage of SketchUp is its extensive ecosystem of plugins and extensions, available through the Extension Warehouse. Tools designed for parametric modelling, structural simulation, and material rendering expand its functionality, making it adaptable to heritage-specific needs (*Boussetta, 2023*). Conservation specialists can apply these plugins to test restoration hypotheses, simulate construction phases, or visualise proposed conservation interventions in relation to existing structures. The ability to evaluate potential restoration outcomes digitally reduces risks of irreversible alterations to fragile heritage sites.

Beyond research and conservation, SketchUp plays an important role in heritage education and community engagement. Its relatively gentle learning curve enables non-specialists, including students and local communities, to participate in heritage documentation projects. Collaborative initiatives in Europe and Latin America have used SketchUp as a participatory tool, training community members to model their local heritage. This not only broadens the knowledge base but also fosters a sense of ownership and responsibility towards cultural preservation. Furthermore, SketchUp models are widely compatible with presentation platforms, enabling export to VR and AR environments. This has led to their incorporation into museum exhibitions, virtual heritage tours, and educational applications, thereby enhancing public access to cultural heritage (*Boussetta, 2023*).

SketchUp's visualisation capabilities also support interpretative reconstructions of lost or altered heritage. For example, in projects addressing World War II–damaged urban heritage in Central Europe, researchers have employed SketchUp to recreate pre-war streetscapes and monuments. These digital reconstructions provide a visual reference for restoration planning and serve as important instruments for memory culture, allowing future generations to engage with heritage that has been partially or completely destroyed.

In addition to architectural applications, SketchUp has been used for object-level modelling of artefacts, particularly in contexts where simplified yet accurate representations are sufficient.

Museum professionals have applied the software to produce 3D models of exhibition layouts, simulating visitor experiences and optimising the display of artefacts. This logistical function demonstrates the software's versatility in supporting not only the preservation of heritage but also its communication and accessibility.

Importantly, SketchUp's balance between usability and technical capability exemplifies how digital tools can democratise cultural heritage preservation. While advanced platforms such as Autodesk 3ds Max or Blender may provide higher levels of precision and photorealism, SketchUp offers a pragmatic alternative that can be employed effectively by teams with limited resources or technical expertise. In this respect, it complements more complex workflows, ensuring that digital heritage documentation and reconstruction are not confined to highly specialised environments.

Thus, SketchUp has established itself as a practical and adaptable tool for cultural heritage preservation, combining ease of use, flexibility, and wide applicability. Its role in architectural documentation, integration with photogrammetric data, plugin-supported functionality, and capacity for educational and participatory projects underscores its value across multiple domains of heritage practice. By enabling both experts and non-specialists to engage in heritage modelling, SketchUp not only supports conservation and restoration but also strengthens the relationship between cultural heritage and the wider community.

Rhinoceros (Rhino)

Rhinoceros, commonly referred to as Rhino, is a versatile 3D CAD software renowned for its precision in modelling complex geometries. In the context of cultural heritage preservation, Rhino has gained significant prominence due to its ability to accurately model architectural structures, artefacts, and intricate ornamental details, providing a reliable digital environment for both research and restoration initiatives. Its robust NURBS-based modelling engine enables the creation of mathematically precise surfaces and curves, making it particularly valuable for documenting geometrically complex heritage objects such as domes, vaults, sculptural elements, and decorative facades (*Acke et al., 2021*).

A key advantage of Rhino in heritage applications is its capacity to integrate heterogeneous data sources, including photogrammetry, LiDAR scans, terrestrial laser scanning, and historical blueprints. This allows researchers and conservators to create highly accurate digital replicas of monuments and artefacts, which serve as essential references for preservation, restoration, and virtual reconstruction. For instance, in projects involving Gothic cathedrals in France and Spain, Rhino was employed to reconstruct complex ribbed vaults and ornamental facades, combining laser scan data with historical drawings to produce geometrically precise models suitable for both analysis and restoration planning (*Acke et al., 2021*).

Rhinoceros' precision is complemented by its compatibility with parametric design tools such as Grasshopper, which allows for algorithmic modelling and structural simulation. In heritage contexts, this functionality enables researchers to explore alternative reconstruction scenarios, assess structural stability, and simulate restoration interventions before physically altering fragile sites. For example, the digital restoration of Renaissance architectural elements in Italian palaces utilised Rhino and Grasshopper to test reintegration strategies for missing or

damaged components, ensuring that conservation decisions were guided by accurate geometric analysis (*Acke et al., 2021*).

Beyond architectural applications, Rhino is also highly effective for object-level modelling and artefact reconstruction. Its precise control over curves and surfaces makes it suitable for reconstructing ceramic vessels, metalwork, sculptures, and decorative motifs. Museums and conservation laboratories have applied Rhino to digitally restore fragmented artefacts, generate 3D models for archival purposes, and create templates for physical replication via 3D printing or CNC milling. For example, in the reconstruction of pre-Columbian ceramic vessels in Latin America, Rhino enabled conservators to restore symmetry, surface texture, and volumetric integrity, providing both a research tool and a digital surrogate for fragile originals (*Acke et al., 2021*).

Rhinoceros' interoperability with other digital heritage tools significantly enhances its applicability. Models produced in Rhino can be exported in multiple formats for integration with GIS, VR/AR environments, and photorealistic rendering platforms such as V-Ray or Blender. This flexibility allows heritage practitioners to combine the geometric precision of Rhino with advanced visualisation and immersive technologies, facilitating both scholarly analysis and public dissemination. Projects involving historical urban landscapes have leveraged Rhino to model building envelopes and street layouts accurately, subsequently integrating these models into VR applications that provide interactive, educational experiences for visitors.

Another notable feature of Rhino is its suitability for documentation and long-term preservation of cultural heritage. Digital models created in Rhino serve as precise records of current conditions, enabling monitoring of structural changes, environmental impacts, and degradation over time. This capability is particularly important for sites at risk from natural disasters, urban development, or climate change, providing heritage authorities with reliable data to inform protective measures and conservation strategies (*Acke et al., 2021*).

Rhinoceros' combination of mathematical accuracy, flexible modelling environment, and compatibility with parametric and visualisation tools makes it a powerful instrument in cultural heritage. By supporting precise reconstruction, structural analysis, and virtual visualisation, Rhino contributes to both the preservation of physical artefacts and monuments and the interpretation of historical and artistic knowledge. Its application extends from architectural monuments to intricate artefacts, bridging the gap between technical documentation, scientific research, and public engagement.

Thus, Rhinoceros (Rhino) exemplifies how advanced CAD technologies can serve the multifaceted needs of cultural heritage preservation. Its precision, adaptability, and interoperability make it indispensable for documenting, reconstructing, and visualising heritage assets, ensuring that both scholarly research and public dissemination are supported by accurate and reliable digital representations. Rhino's capabilities enable conservators, archaeologists, and educators to safeguard the material and intangible dimensions of cultural heritage for future generations.

Below the authors present an expanded program table for 3D graphic design with an emphasis on use in the restoration and documentation of cultural heritage sites (*Table 3*).

Table 2. An expanded program table for 3D graphic design with an emphasis on use in the restoration and documentation of cultural heritage sites:

Software / Technology	Type	Purpose in Cultural Heritage	Advantages	Practical Examples
Autodesk 3ds Max	3D	Detailed 3D modeling and animation of artifacts and monuments	Advanced modeling, texturing, rendering; integration with CAD and photogrammetry	Virtual reconstruction of temples, statues, and historical sites
Blender	3D	3D modeling, rendering, and animation	Free, sculpting, texture mapping, large plugin community	Creating interactive virtual museum exhibits, reconstructing archaeological sites
Autodesk Maya	3D	Complex 3D modeling and simulation	Professional animation and rendering; supports integration with photogrammetry	Reconstruction of historical structures, visual simulation of site restorations
ZBrush	3D	Digital sculpting of artifacts	High-resolution polygonal modeling, precise surface detailing	Reconstructing statues, reliefs, and intricate decorative objects
SketchUp	3D	Architectural modeling, virtual excavation and landscapes	Intuitive interface, fast visualization, suitable for education	Virtual reconstruction of archaeological buildings and historical landscapes
Rhinoceros	3D	Precise modeling for artifacts and structures	NURBS modeling, CAD/CAM integration, high compatibility	Creating models for 3D printing of replicas, structural analysis for restoration

Digital Tools and Software for Archaeological Site Detection and Documentation

The integration of digital technologies into archaeological research has considerably expanded the methods available for site discovery, documentation, and interpretation. GISs, such as ArcGIS and QGIS, have become indispensable for spatial analysis, enabling archaeologists to combine multiple datasets and predict the location of potential sites (*Lock & Pouncett, 2017*; *Menéndez-Marsh et al., 2023*; *Conolly, 2012*). Similarly, satellite image processing software like ENVI provides powerful tools for identifying subtle landscape anomalies, often invisible to the naked eye, that may indicate ancient human activity (*Luo et al., 2022*; *Luo et al., 2023*).

Equally important are technologies that allow precise recording and reconstruction. Photogrammetry tools such as Agisoft Metashape (*Chapinal-Heras et al., 2024*; *Jones & Church, 2020*) and design software like AutoCAD (*Buna et al., 2014*; *Green et al., 2016*; *Zhao & Lyu, 2021*) support the creation of highly detailed 3D models of excavation sites, artefacts, and architectural remains. In parallel, LiDAR-based applications (e.g., LAStools, CloudCompare) have revolutionised fieldwork by revealing hidden structures beneath dense vegetation (*Casana et al., 2021*; *Inomata, 2024*; *Vilbig et al., 2020*), leading to discoveries on a scale previously unimaginable. A notable example is the uncovering of vast networks of Maya cities in Guatemala, which had remained undetected for centuries beneath rainforest canopies (*Vilbig et al., 2020*).

Non-invasive methods, including drone-based surveying platforms (DroneDeploy, Pix4D) (*Documenting…, 2017*; *Using…, 2022*; *Mapping megaliths…, 2025*) and geophysical software (Geoplot, TerraSurveyor) (*GeoPlot: About, 2007*; *Sensing…, 2015*; *New Philadelphia…, n.d.*), complement these approaches by offering rapid, accurate, and minimally destructive techniques for exploring archaeological landscapes. For instance, drone surveys have been employed to

map Roman roads across Britain, while geophysical prospection has enabled the discovery of Iron Age and medieval burial grounds in Central and Eastern Europe without disturbing the soil (*Kvamme, 2018*). Together, these digital tools represent a shift towards more sustainable and comprehensive archaeological practices, where discovery, preservation, and interpretation are tightly interlinked.

Table 3. Digital tools and software for archaeological site detection and documentation

Software / Technology	Main Purpose	Advantages	Use in Archaeology
ArcGIS / QGIS	Geographic Information Systems (GIS)	Handles large datasets, 3D maps, layers; QGIS is free	Landscape analysis, prediction of archaeological sites, map creation
Agisoft Metashape	Photogrammetry and 3D modelling	High accuracy of 3D models, easy processing of photographs and aerial images	Reconstruction of excavation areas, artefacts, architecture
AutoCAD / Autodesk ReCap	2D/3D design and reconstruction	Engineering precision, integration with laser scanning	Reconstruction of buildings, creation of virtual models
ENVI	Satellite image processing	Works with multispectral and hyperspectral data, detects hidden structures	Identification of settlements, Roman roads, burial mounds through vegetation and soil changes
LiDAR (LAStools, CloudCompare)	Laser scanning of terrain	Reveals features beneath vegetation, high-resolution detail	Discovery of Maya cities in Guatemala, burial mounds, ramparts, hillforts
DroneDeploy / Pix4D	Aerial surveying with drones	Rapid mapping, integration with 3D and GIS	Mapping Roman roads in Britain, surveying remote areas, documenting the condition of monuments
Geoplot / TerraSurveyor	Geophysical prospection (magnetometry, ground-penetrating radar)	"Non-invasive excavation", high sensitivity to anomalies	Discovery of Iron Age settlements and medieval burials in Europe, detection of foundations, underground structures

ArcGIS and QGIS

GISs, represented by commercial software such as ArcGIS and its open-source counterpart QGIS, have become indispensable tools in contemporary archaeology. Their principal strength lies in the ability to integrate, manage, and analyse spatial data from a wide range of sources, including satellite imagery, aerial surveys, geophysical prospection, and excavation records (*Conolly, 2012*; *Menéndez-Marsh et al., 2023*; *Ciccone, 2024*; *Duarte et al., 2018*). By structuring archaeological data within layered geospatial frameworks, these systems allow researchers to uncover patterns that would otherwise remain hidden when using conventional mapping techniques.

One of the key advantages of ArcGIS is its comprehensive suite of analytical tools, ranging from spatial statistics and predictive modelling to sophisticated 3D visualisation. QGIS, while being free and open-source, has developed into a comparably powerful platform, particularly through its extensive library of community-driven plugins (*Duarte et al., 2018*; *Ciccone, 2024*). This makes it highly adaptable to different research contexts, including field survey, cultural heritage management, and predictive modelling of settlement patterns. The possibility of integrating

historical cartography with modern remote-sensing data enhances the accuracy of site localisation, while temporal analysis enables archaeologists to explore changes in landscapes over centuries or millennia.

From a practical perspective, GIS technologies significantly improve efficiency in both research and conservation. They allow the creation of detailed digital maps of archaeological landscapes, which can be continuously updated as new data emerges. In cultural resource management, GIS is widely employed to assess the potential impact of modern infrastructure projects on archaeological heritage, thereby contributing to its preservation. Moreover, predictive models generated in GIS environments have facilitated the identification of sites in regions that have not yet been systematically excavated, reducing the need for invasive exploration (*Menéndez-Marsh et al., 2023*; *Nicu et al., 2019*).

Thus, ArcGIS and QGIS represent more than mapping tools: they serve as integrative platforms for data-driven archaeology. By enabling researchers to visualise, analyse, and interpret complex spatial relationships, they provide critical insights into human-environment interactions, settlement dynamics, and cultural landscapes. In doing so, they have transformed archaeological practice into a more precise, systematic, and predictive discipline.

Agisoft Metashape

Agisoft Metashape, formerly known as Agisoft Photoscan, is one of the leading photogrammetric software packages employed in archaeology. Its principal function lies in the generation of accurate 3D models from 2D photographic data (*Chapinal-Heras et al., 2024*; *Jones & Church, 2020*; *Kostrzewa et al., 2025*), a technique that has become central to modern archaeological documentation and interpretation. By using overlapping sets of photographs, captured either from the ground or through aerial platforms such as drones, Metashape reconstructs the geometry of archaeological sites, features, and artefacts with a level of precision that rivals, and in many cases surpasses, traditional surveying methods.

A significant advantage of Metashape is its accessibility: although highly sophisticated, it is relatively user-friendly and does not require advanced technical knowledge to produce scientifically valuable results (*Howland et al., 2014*). The software is capable of generating orthophotos, DEMs, and textured 3D meshes that can be integrated into wider GIS environments or used independently for analytical and presentation purposes. These outputs provide archaeologists with not only detailed visual records but also measurable datasets, enabling accurate assessment of spatial relationships and volumetric properties of features and objects.

The application of Metashape in archaeology extends from field excavation to heritage conservation. At excavation sites, it allows the creation of daily or weekly 3D updates of trenches, thereby offering a dynamic record of stratigraphic changes that can be revisited long after fieldwork is completed. In the context of artefacts, Metashape facilitates the creation of digital replicas, which can be shared with the global scholarly community or exhibited in virtual museums, contributing to broader accessibility of cultural heritage. Furthermore, the non-invasive nature of photogrammetry ensures that fragile structures or objects can be documented without physical interference.

Metashape's strength also lies in its adaptability to different scales. It can be used to model individual artefacts, architectural remains, or entire landscapes surveyed by drones. This flexibility makes it an indispensable tool for projects ranging from small-scale excavations to large territorial studies. By bridging precision recording with visual communication, Metashape has reshaped archaeological methodology, enabling the discipline to move towards more transparent, reproducible, and collaborative research practices (*Bornstein & Keep, 2023*; *Kingsland, 2020*).

AutoCAD and Autodesk ReCap

AutoCAD and Autodesk ReCap occupy an important niche within digital archaeology, particularly in the domain of architectural documentation, structural analysis, and 3D reconstruction (*Buna et al., 2014*; *Green et al., 2016*; *Zhao & Lyu, 2021*). AutoCAD, originally developed as a design and engineering tool, has long been adapted for archaeological purposes because of its capacity to produce precise technical drawings and models of ancient structures. Autodesk ReCap complements this process by enabling the transformation of laser scans and photogrammetric data into workable 3D models, which can then be refined and analysed in AutoCAD. Together, these tools provide archaeologists with the means to document and reconstruct architectural remains with an accuracy that was previously unattainable.

The strength of AutoCAD lies in its precision and standardisation. Archaeologists and heritage specialists can create detailed 2D and 3D representations of excavation areas, standing architecture, or reconstructed monuments. These drawings are not merely illustrative but serve as analytical resources, allowing scholars to test structural hypotheses, measure architectural components, and compare construction techniques across sites. Autodesk ReCap adds value by processing raw data collected from terrestrial laser scanners or drones, converting millions of spatial points into structured point clouds and meshes. This integration streamlines the workflow from field data collection to technical modelling.

In archaeological practice, these applications have proven invaluable for the reconstruction of collapsed or eroded buildings, temples, and urban layouts. They support heritage conservation efforts by offering detailed baseline documentation, which can later be used for restoration projects or digital preservation in cases where the original structures are endangered. Moreover, 3D reconstructions produced with AutoCAD and ReCap enhance public engagement by enabling immersive visualisations for museums, exhibitions, and educational platforms.

Perhaps most importantly, the combination of these tools advances methodological transparency. Digital reconstructions can be revisited, revised, and enriched as new evidence emerges, creating dynamic rather than static interpretations. By bridging engineering-level precision with archaeological interpretation, AutoCAD and Autodesk ReCap significantly contribute to the preservation, study, and communication of ancient built environments.

ENVI

ENVI is a specialised software platform designed for the processing and analysis of satellite and aerial imagery, with particular relevance to archaeological research in remote sensing (*Luo et al., 2022*; *Luo et al., 2023*). Its core capability lies in the manipulation of multispectral and

hyperspectral data, enabling the detection of subtle anomalies in vegetation, soil composition, and topography that are indicative of past human activity. By transforming spectral information into interpretable visualisations, ENVI allows archaeologists to identify sites and features that are often invisible to the naked eye or obscured by natural or modern landscape changes.

One of the key advantages of ENVI is its sophisticated suite of analytical tools, including spectral classification, change detection, and terrain analysis. These functions facilitate the systematic examination of large areas, making it possible to prioritise field surveys and target areas with high potential for archaeological discovery. For example, differential vegetation patterns over buried structures or ancient roads can be quantified and mapped, providing indirect evidence of subsurface remains. This predictive capability is particularly valuable in regions where excavation is limited by accessibility, legal restrictions, or preservation concerns.

ENVI's utility extends beyond site discovery. Its integration with GISs enables the combination of remote sensing data with historical maps, survey data, and environmental variables, supporting comprehensive landscape analysis. Archaeologists can examine spatial relationships between settlements, water sources, and transportation networks, providing insights into ancient settlement patterns, land use, and environmental adaptation. Additionally, ENVI facilitates temporal studies, allowing researchers to monitor changes in landscapes over decades or centuries, which is instrumental in understanding site degradation, urban expansion, or agricultural impacts.

In practical applications, ENVI has been successfully used to detect previously unknown settlement sites, map ancient agricultural systems, and trace historic road networks. Its non-invasive nature ensures minimal disturbance to sensitive archaeological contexts while providing robust, reproducible data. By combining quantitative spectral analysis with spatial interpretation, ENVI exemplifies how advanced remote sensing technology can enhance both the efficiency and the scientific rigour of archaeological investigations.

LiDAR (LAStools, CloudCompare)

LiDAR technology has emerged as a transformative tool in contemporary archaeology, particularly in the detection and documentation of topographic and structural features that are obscured by dense vegetation or difficult terrain (*Inomata, 2024*; *Vilbig et al., 2020*; *Vinci et al., 2024*; *Casana et al., 2021*). LiDAR operates by emitting laser pulses from aerial platforms, such as drones or aircraft, and measuring the time taken for the pulses to return after reflecting off the ground or objects. The resulting point cloud data is then processed using software such as LAStools and CloudCompare, which enables the generation of highly accurate 3D digital models of the terrain, revealing features that are otherwise invisible through conventional survey methods.

One of the primary advantages of LiDAR is its capacity to penetrate forest canopies and other surface cover, allowing archaeologists to detect subtle earthworks, ancient roads, ramparts, burial mounds, and building foundations with remarkable precision (*Vinci et al., 2024*; *Vilbig et al., 2020*). LAStools provides an efficient suite of algorithms for the filtering, classification, and visualisation of massive point cloud datasets, while CloudCompare offers advanced 3D comparison and analysis functions, enabling detailed morphometric and

volumetric measurements of identified features. This combination significantly enhances the analytical power of field archaeology and landscape studies.

In practice, LiDAR has revolutionised archaeological exploration in areas previously considered inaccessible or too challenging for traditional survey techniques. A notable example is the discovery of extensive Maya urban networks in Guatemala, where LiDAR data revealed thousands of previously undocumented structures hidden beneath dense rainforest canopies (*Casana et al., 2021*). Similarly, in Europe, LiDAR surveys have been employed to map prehistoric hillforts, medieval field systems, and Roman infrastructure with unprecedented detail, facilitating both heritage management and academic research.

Beyond discovery, LiDAR data supports the long-term preservation and interpretation of archaeological sites. Digital elevation models derived from LiDAR allow researchers to monitor erosion, land-use changes, and other environmental impacts on cultural heritage sites. Furthermore, the high-resolution 3D models produced can be shared digitally, promoting broader accessibility and enabling virtual reconstruction, education, and public engagement. By integrating LiDAR technology with robust software analysis, archaeologists have gained a powerful non-invasive method to explore, document, and protect the world's archaeological heritage.

DroneDeploy and Pix4D

Drone-based photogrammetry platforms, such as DroneDeploy and Pix4D, have become increasingly important in modern archaeological research due to their ability to capture high-resolution aerial imagery over extensive or inaccessible areas (*Digital tools…, 2024*; *Documenting…, 2017*; *Using…, 2022*; *Mapping megaliths…, 2025*; *Mapping the past, 2023*; *Drone Surveying…, 2024*). These software platforms facilitate the processing of drone-acquired images into orthophotos, DEMs, and 3D reconstructions, offering archaeologists a rapid and non-invasive means of surveying landscapes and sites. The combination of lightweight UAVs with sophisticated image-processing software has significantly expanded the scale and efficiency of field investigations.

One of the primary advantages of DroneDeploy and Pix4D is their versatility and adaptability to different survey requirements. They allow for precise mapping of large territories within relatively short time frames, while maintaining high spatial resolution and geometric accuracy. The generated data can be integrated with GIS platforms or photogrammetric tools to analyse spatial patterns, detect subtle topographical anomalies, and identify previously undocumented archaeological features. For example, crop marks, soil discoloration, or micro-relief variations may indicate buried structures or pathways, which can then be targeted for further investigation (*Fiz et al., 2022*).

In addition to site detection, these platforms play a critical role in heritage documentation and monitoring. Repeated drone surveys can provide temporal datasets that track changes in site conditions, erosion, vegetation growth, or human impact. This capability is particularly valuable for endangered or highly sensitive sites where traditional survey methods may be intrusive or impractical. Moreover, the outputs—orthophotos, 3D models, and georeferenced maps—can be shared digitally, supporting collaborative research, remote analysis, and public engagement initiatives such as virtual tours or educational materials.

DroneDeploy and Pix4D also enhance safety and logistical efficiency. Archaeologists can survey difficult terrains, steep slopes, wetlands, or conflict-affected regions without physically entering hazardous zones. By integrating aerial imagery with other geospatial datasets, researchers can conduct multi-layered analyses, improving the predictive modelling of site locations and landscape interactions. Overall, drone-based photogrammetry platforms represent a paradigm shift in archaeological methodology, enabling comprehensive, precise, and non-destructive investigation of cultural heritage across diverse environmental contexts.

Geoplot and TerraSurveyor

Geophysical prospection software, such as Geoplot and TerraSurveyor, has become an essential tool in non-invasive archaeological investigation, allowing researchers to detect subsurface features without disturbing the soil (*GeoPlot: About, 2007*; *Sensing…, 2015*; *New Philadelphia…, n.d.*; *TerraSurveyor64, n.d.*; *Kvamme, 2018*). These platforms are designed to process and visualise data collected from a variety of geophysical survey techniques, including magnetometry, GPR, resistivity, and electromagnetic induction. By converting raw geophysical signals into interpretable visual outputs, the software enables archaeologists to identify buried structures, pits, walls, tombs, and other features that are not visible on the surface.

A principal advantage of Geoplot and TerraSurveyor lies in their analytical flexibility. The software allows for the integration and comparison of datasets from multiple survey methods, enhancing the reliability and interpretability of results. High-resolution gridded maps and 3D models generated from geophysical data can reveal subtle anomalies corresponding to archaeological features, providing a detailed spatial understanding of subsurface contexts. Furthermore, advanced filtering, smoothing, and statistical analysis tools help distinguish between cultural features and natural geological variations, reducing false positives and improving targeting for subsequent excavation.

In practical applications, these tools have facilitated significant archaeological discoveries across a range of environments. For example, magnetometry surveys processed in Geoplot have revealed Iron Age settlements and Roman villas in Europe, while GPR surveys analysed with TerraSurveyor have located medieval burials and ancient road networks. Such discoveries often occur without any soil disturbance, preserving the integrity of fragile archaeological contexts. Additionally, the non-invasive nature of geophysical prospection supports heritage management, permitting rapid assessment of site extent, condition, and potential threats before excavation or conservation interventions.

Beyond discovery, the software also enables long-term monitoring and documentation. Processed geophysical datasets can be integrated into GIS platforms for spatial analysis, comparison with historical maps, or predictive modelling of unexcavated areas. By combining precision, efficiency, and minimal environmental impact, Geoplot and TerraSurveyor exemplify how modern geophysical software contributes to systematic, evidence-based, and sustainable archaeological practice.

Thus, the study and utilisation of digital tools and software in archaeological research are of paramount importance for the preservation, documentation, and interpretation of cultural heritage. As demonstrated in the analysis, GISs such as ArcGIS and QGIS provide archaeologists with the capacity to integrate, manage, and analyse spatial data from diverse

sources, enabling predictive modelling and comprehensive landscape assessments. Photogrammetric software, including Agisoft Metashape, alongside design tools like AutoCAD and Autodesk ReCap, ensures precise 3D documentation of excavation sites, artefacts, and architectural remains, facilitating both scholarly analysis and the creation of virtual reconstructions accessible to the broader public.

Remote sensing platforms, exemplified by ENVI and LiDAR applications such as LAStools and CloudCompare, reveal previously hidden or inaccessible structures, significantly expanding the scope of archaeological discovery while preserving the integrity of sites. Similarly, drone-based surveying software, including DroneDeploy and Pix4D, allows rapid, high-resolution mapping of extensive or difficult-to-access areas, generating datasets that can be integrated with GIS and photogrammetric outputs for multi-layered analyses. Geophysical prospection tools, such as Geoplot and TerraSurveyor, further complement these approaches by providing non-invasive methods to detect subsurface features, reducing the need for intrusive excavation and supporting heritage management strategies.

Collectively, these digital technologies foster a shift towards sustainable and evidence-based archaeological practices. They not only enhance the efficiency, precision, and reproducibility of research but also contribute to the long-term preservation of cultural heritage by enabling detailed monitoring, virtual reconstruction, and informed decision-making in conservation efforts. Therefore, the integration of these software tools is essential for modern archaeology, ensuring that discoveries are systematically documented, risks to fragile sites are minimised, and cultural heritage is safeguarded for future generations.

Discussion

The current study has highlighted the transformative impact of digital graphics software on the field of cultural heritage restoration. The relevance of this topic cannot be overstated, given the escalating threats to both tangible and intangible heritage worldwide. Digital tools have moved beyond mere support functions, becoming integral to the very methodology of preservation. The ability to create detailed, non-invasive digital replicas offers a crucial alternative to traditional, often destructive, documentation methods. This shift is particularly vital in situations where physical access is limited or the object is too fragile for direct contact. However, despite these advancements, the author of this paper encountered several challenges. A primary limitation is the inherent bias towards widely used commercial software, which may overshadow the significant contributions of open-source alternatives. The analysis, while comprehensive in its coverage of major platforms, could have benefited from a more in-depth comparison of their cost-effectiveness, accessibility, and community support. Furthermore, the paper's reliance on existing case studies, while necessary, presents a potential limitation. It does not include an original empirical study, which could have provided direct, first-hand data on the effectiveness and challenges of these tools in practice. The pace of technological evolution is another key challenge; new software and updates are released frequently, making a definitive, long-term assessment difficult. This necessitates a continuous review of tools and techniques to ensure research remains current.

Looking ahead, this study opens up several avenues for future research. A critical question is the long-term sustainability of digital archives. As software becomes obsolete and file formats

change, how can we ensure that the digital reconstructions and documentation from today will be accessible and usable for future generations? Further research is also needed to address the standardisation of digital documentation protocols across different institutions and projects to ensure interoperability and data consistency. Researchers should also investigate the economic and logistical barriers to adopting these technologies in less affluent regions and for smaller projects. Finally, the ethical implications of digital reconstruction—specifically, the challenge of interpreting and representing missing or ambiguous historical data—are a crucial area for future scholarly debate.

Conclusion

This study has demonstrated that digital graphics software is a fundamental tool for documentation, reconstruction, and visualisation in cultural heritage restoration. By analysing a range of 2D and 3D platforms, this paper has highlighted their capacity to facilitate precise and non-invasive methods of recording and preservation. The transition to digital workflows not only enhances the accuracy of documentation but also democratises access to historical objects, allowing for their study and appreciation by a wider audience, including the general public and international researchers. The creation of detailed 3D models from laser scans and photogrammetry, in particular, offers a powerful means of digitally restoring structures and artefacts that are damaged or no longer exist. This capability is vital for cultural preservation, as it safeguards historical data against future loss and provides new avenues for scholarly inquiry.

The key finding is that these digital tools are not merely aids to illustration but are essential components of a new, scientifically rigorous methodology. They provide a platform for complex analysis, enabling researchers to simulate historical environments and test hypotheses regarding structural integrity, material decay, and original design. The interoperability between different software types further strengthens this approach, fostering interdisciplinary collaboration among historians, archaeologists, architects, and computer scientists. In conclusion, the application of digital graphics software represents a paradigm shift in cultural heritage restoration. It allows us to move beyond passive documentation to an active, dynamic form of preservation that is both scientifically robust and widely accessible. The digital revolution offers a powerful and sustainable means of ensuring that the narratives and material evidence of our shared past endure for future generations, serving as an irreplaceable resource for education, research, and cultural appreciation.

Conflict of Interest

The authors declare that there is no conflict of interest.

References:

A review of recent advances in GIS applications for archaeology. (1998). Chicago: National Center for Preservation Technology and Training.

Acke, L., De Vis, K., Verwulgen, S., & Verlinden, J. (2021). Survey and literature study to provide insights on the application of 3D technologies in cultural heritage conservation-restoration. *Journal of Cultural Heritage*, 49, 272-288. https://doi.org/10.1016/j.culher.2020.12.003

Autodesk. (2024a). Autodesk Maya. *Heritage Innovation Lab*. https://marketplace.heritageinnovation.eu/product/autodesk-maya/

Autodesk. (2024b). Sustainable Architectural Preservation. *Autodesk*. https://www.autodesk.com/solutions/aec/architectural-preservation/

Bornstein, D., & Keep, T. J. (2023). New Dimensions in Conservation Imaging: Combining Photogrammetry and Photometric Stereo for 3D Documentation of Heritage Artefacts. *AICCM Bulletin*, *44*(1–2), 148–162. https://doi.org/10.1080/10344233.2023.2288467

Boussetta, B. (2023, April 19). 3D modeling and cultural heritage: Preserving the past through digital reconstruction. *Medium*. https://medium.com/%40badreddinebousseta/3d-modeling-and-cultural-heritage-preserving-the-past-through-digital-reconstruction-ce0695260504

Buna, Z., Popescu, D., Comes, R., Badiu, I., & Mateescu, R. (2014). Engineering CAD tools in digital archaeology. *Mediterranean Archaeology and Archaeometry*, *14*, 83–91.

Buychik, A. (2020). Klironomy as a systematic scientific approach to the preservation of cultural heritage: its place in the educational system. *Scientific Trends: Philology, Cultural Studies, Art History. Collection of Scientific Papers Based on the Materials of the 19th International Scientific and Practical Conference*, 29–34. (In Russ.)

Buychik, A. (2021). The relevance of the formation of the science of the cultural heritage preservation as the evolution of social and scientific thought. *Scientific View on the Modern Problems of Cultural Heritage and Arts in the Context of Social Development. Proceedings of the International Scientific Conference. Klironomy*, *1*(1), 7–21. https://doi.org/10.47451/her2021-06-001

Buychik, A. (2024). *Klironomy: The Science of Cultural Heritage*. Ostrava: Tuculart Edition, European Institute for Innovation Development.

Casana, J., Laugier, E. J., Hill, A. C., Reese, K. M., Ferwerda, C., McCoy, D., & Ladefoged, T. (2021). Exploring archaeological landscapes using drone-acquired lidar: Case studies from Hawai'i, Colorado, and New Hampshire, USA. Journal of Archaeological Science: Reports, 39, 103133. https://doi.org/10.1016/j.jasrep.2021.103133

Chapinal-Heras, D., Díaz-Sánchez, C., Gómez-García, N., España-Chamorro, S., Pagola-Sánchez, L., López de Corselas, M. P., & Rey-Álvarez Zafiria, M. E. (2024). Photogrammetry, 3D modelling and printing: The creation of high-quality 3D models for cultural heritage conservation. *Digital Applications in Archaeology and Cultural Heritage*, *33*, e00341. https://doi.org/10.1016/j.daach.2024.e00341

Charbonneau, N., Spiric, N., Blais, V., Robichaud, L., & Burgess, J. (2018). 4D modelling of built heritage: A system offering an alternative to using BIM. *Digital Studies*, *8*, 8. https://doi.org/10.16995/dscn.283

Ciccone, G. (2024). Using QGIS as an ideal workspace for archaeogeography: A case study on Castronovo di Sicilia. *Proceedings*, *96*(1), 11. https://doi.org/10.3390/proceedings2024096011

Conolly, J. (2012). *Geographical information systems in archaeology*. Cambridge University Press. https://doi.org/10.1017/CBO9780511807459

Digital Tools for Cultural Heritage Preservation. (2024, November 28). *Pix4D*. https://www.pix4d.com/blog/digital-tools-heritage-preservation-pix4dcatch/

Documenting Archaeological Sites with Drone Mapping. (2017, October 19). *Pix4D*. https://www.pix4d.com/blog/documenting-large-complex-archaeological-environments-drone-mapping/

Drone Surveying 101: From GSD to Point Clouds. (2024, May 15). *DroneDeploy*. https://www.dronedeploy.com/blog/drone-surveying-101-from-gsd-to-point-clouds/

Duarte, L., Gomes, A., Teodoro, A. C., & Monteiro-Rodrigues, S. (2018). QGIS approach to extract fluvial terraces for archaeological purposes using remote sensing data. *FOSS4G-Europe 2018 Conference Proceedings*, *18*. https://doi.org/10.7275/9csb-0e44

Finding Secrets of the Past with Drones and Mobile Scans. (2022, May 2025). *Pix4D*. https://www.pix4d.com/blog/uncovering-archaeological-sites-with-drones-mobile-phones/

Fiz, J. I., Martín, P. M., Cuesta, R., Subías, E., Codina, D., & Cartes, A. (2022). Examples and results of aerial photogrammetry in archeology with UAV: Geometric documentation, high resolution multispectral analysis, models and 3D printing. *Drones*, *6*(3), 59. https://doi.org/10.3390/drones6030059

GeoPlot: About. (2007). *CAIDA*. https://www.caida.org/catalog/software/geoplot/

Green, K., Niven, K., & Field, G. (2016). Migrating 2 and 3D datasets: Preserving AutoCAD at the archaeology data service. *ISPRS International Journal of Geo-Information*, *5*(4), 44. https://doi.org/10.3390/ijgi5040044

Howland, M., Kuester, F., & Levy, T. (2014). Photogrammetry in the field: Documenting, recording, and presenting archaeology. *Mediterranean Archaeology and Archaeometry*, *14*, 101–108.

Inomata, T. (2024). Lidar, space, and time in archaeology: Promises and challenges. *Annual Review of Anthropology*, 53, 75–92. https://doi.org/10.1146/annurev-anthro-041222-093758

Jones, C. A., & Church, E. (2020). Photogrammetry is for everyone: Structure-from-motion software user experiences in archaeology. *Journal of Archaeological Science: Reports*, *30*, 102261. https://doi.org/10.1016/j.jasrep.2020.102261

Kingsland, K. (2020). Comparative analysis of digital photogrammetry software for cultural heritage. *Digital Applications in Archaeology and Cultural Heritage*, *18*, e00157.

Kostrzewa, A., Płatek-Żak, A., Banat, P., & Wilk, Ł. (2025). Open-source vs. commercial photogrammetry: Comparing accuracy and efficiency of OpenDroneMap and Agisoft Metashape. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLVIII-1/W4-2025*, 65–72. https://doi.org/10.5194/isprs-archives-XLVIII-1-W4-2025-65-2025

Kvamme, K. (2018). Getting around the Black Box: Teaching (geophysical) data processing through GIS. *Journal of Computer Application in Archaeology*, *1*, 74–87. https://doi.org/10.5334/jcaa.14

Lock, G., & Pouncett, J. (2017). Spatial thinking in archaeology: Is GIS the answer? Journal of Archaeological Science, 84, 129–135. https://doi.org/10.1016/j.jas.2017.06.002

Luo, L., Wang, X., & Guo, H. (2022). Remote sensing archaeology: The next century. *Innovation (Cambridge (Mass.))*, *3*(6), 100335. https://doi.org/10.1016/j.xinn.2022.100335

Luo, L., Wang, X., Guo, H., Jia, X., & Fan, A. (2023). Earth observation in archaeology: A brief review. *International Journal of Applied Earth Observation and Geoinformation*, *116*, 103169. https://doi.org/10.1016/j.jag.2022.103169

Mapping Megaliths in 3D: Digital Tools for Archaeology. (2025, May 7). *Pix4D*. https://www.pix4d.com/blog/3d-mapping-digital-tools-archaeology/

Mapping the Past: Pix4D and the Future of Archaeology. (2023, December 19). *Pix4D*. https://www.pix4d.com/blog/Mapping-the-past-pix4d-archaeology/

Menéndez-Marsh, F., Al-Rawi, M., Fonte, J., Dias, R., Gonçalves L. J., Gonçalves Seco, L., Hipólito, J., Machado, J. P., Medina, J., Moreira, J., Pereiro, T. do, Vázquez, M., & Neves, A. (2023). Geographic information systems in archaeology: A systematic review. *Journal of Computer Application in Archaeology*, *6*(1), 40–50. https://doi.org/10.5334/jcaa.104

New Philadelphia Archaeological Project. (n.d.). *Jistorical Archeaology*. https://www.histarch.illinois.edu/np/geophys_method_data.html

Nicu, I. C., Mihu-Pintilie, A., & Williamson, J. (2019). GIS-based and statistical approaches in archaeological predictive modelling (NE Romania). *Sustainability*, *11*(21), 5969. https://doi.org/10.3390/su11215969

Penjor, T., Banihashemi, S., Hajirasouli, A., & Golzad, H. (2024). Heritage building information modeling (HBIM) for conservation of cultural heritage buildings. *Digital Applications in Archaeology and Cultural Heritage*, *35*, e00366. https://doi.org/10.1016/j.daach.2024.e00366

Petras, E. (2021, April 3). Creating a 3D Map of an archaeological site in Blender. *Temple*. https://sites.temple.edu/tudsc/2021/04/03/creating-a-3d-map-of-an-archaeological-site-in-blender/

Sensing the Iron Age and Roman past: Geophysics and the landscape of Hertfordshire. (2015, September 7). *Hertfordshire Archaeology*. https://hertsgeosurvey.wordpress.com/tag/terrasurveyor/

Soto-Martín, O. (2013). 3D reconstruction & traditional illustrations, a non-invasive resource for the practice and teaching of conservation and restoration of cultural heritage. *Procedia Computer Science*, *25*, 247–250. https://doi.org/10.1016/j.procs.2013.11.030

TerraSurveyor64. (n.d.). *DW Consulting*. https://dwconsulting.nl/terrasurveyor64/

Using Drone Technology for Academic Research at the University of Pennsylvania. (2022, March 16). *DroneDeploy*. https://www.dronedeploy.com/blog/the-university-of-pennsylvania/

Vilbig, J. M., Sagan, V., & Bodine, C. (2020). Archaeological surveying with airborne LiDAR and UAV photogrammetry: A comparative analysis at Cahokia Mounds. *Journal of Archaeological Science: Reports*, *33*, 102509. https://doi.org/10.1016/j.jasrep.2020.102509

Vinci, G., Vanzani, F., Fontana, A., & Campana, S. (2024). LiDAR applications in archaeology: A systematic review. *Archaeological Protection*, *32*, 81–101. https://doi.org/10.1002/arp.1931

Waas, M. (2014). Practical 3D photogrammetry for the conservation and documentation of cultural heritage. *Proceedings of the 18th International Conference on Cultural Heritage and New Technologies 2013*.

Yang, C., & Liu, Y. (2024). Preserving sculptural heritage in the Era of Digital Transformation. *Sustainability*, *16*(13), 5349. https://doi.org/10.3390/su16135349

Zhang, J., Liu, Z., & Liu, S. (2019). Computer simulation of archaeological drawings. *Journal of Cultural Heritage*, 37, 181–191. https://doi.org/10.1016/j.culher.2018.11.014

Zhao, Q., & Lyu, Q. (2021). The application of AutoCAD in the drawing of archaeological artifacts—line plot surveying and mapping of standard and complete artifacts. *2021 International Conference on Applications and Techniques in Cyber Intelligence*, 429–436. https://doi.org/10.1007/978-3-030-79200-8_62

Petkova, E. [a][3]

A SYSTEM OF INDICATORS FOR MONITORING SUSTAINABLE TOURISM DEVELOPMENT OF TOURISM DESTINATIONS [2]

Abstract: Tourism is influenced by a wide range of factors and have an impact on sustainable development of a destination. The indicators for sustainable tourism development have been used to assess the impact of tourism on economic, social, and ecological aspects of a destination. The study aims to develop a scientifically based and practically applicable system of indicators for monitoring the sustainable tourism development of destinations. To achieve the purpose, an identification and critical review of scientific literary sources has been performed. Publications, which present systems of indicators for monitoring sustainable tourism development have been selected. Requirements for the selection of the indicators have been specified. Specific criteria have been formulated, on which basis exemplary socio-economic and environmental indicators have been classified in groups. Thus, a system of indicators for monitoring sustainable tourism have been developed. The socio-economic indicators for sustainable tourism development of destinations are related to tourism supply and demand, revenues and costs. The environmental sustainability indicators are related to the types of and impacts on natural resources.

Keywords: sustainable tourism, monitoring, social, economic, environmental indicators.

Introduction

Tourism is a very complex system that is developing in time and space. During its development, on the one hand, tourism system is influenced by the factors of the surrounding environment, and on the other hand, it has positive and negative impacts on it. These basic characteristics of tourism system require efforts for its management at national, regional and local levels to be made; and any management depends on the availability of sufficient, detailed, quality, up-to-date, and timely information for making informed decisions. Data on tourism development of destinations should be complete and reliable. It should enable a complete picture of tourism development to be drawn. The information system should fully reflect the complex essence of tourism, and the information about the impacts on the environment where tourism develops should be complete and systemized. All that requires the consideration of economic, social and environmental importance of tourism, which would lead to sufficient attention to the sector, including in terms of destination marketing. It is necessary to collect, process, and analyze information related to sustainable tourism development. The accumulated information and knowledge would represent a solid basis for a clear conceptualization and development of a working monitoring system of the tourism development of destinations. For the needs of providing information for forecasting and planning the sustainable tourism development of destinations, necessary and sufficient indicators should be selected. The system of indicators for monitoring sustainable tourism development should be based on considering the systematic nature and structure of tourism, the models of tourism development and the impacts of tourism through the prism of the concept of sustainable tourism development.

[a] Elena Petkova, Associate Professor, Ph.D. in Economics and Management of Tourism, Department of Geography of Tourism, Faculty of Geology and Geography, Sofia University "St. Kliment Ohridski". Sofia, Bulgaria.
ORCID 0000-0003-3232-6104. E-mail: epetkova@gea.uni-sofia.bg

The study aims to develop a scientifically-based and practically-applicable system of indicators for monitoring the sustainable tourism development of destinations. The range of indicators in the system should include indicators of the state of tourism system and its elements, indicators of the conditions and factors of the surrounding environment and indicators of the impact of tourism on the environment. For the purpose of the study, an identification and critical review of scientific literary sources have been performed. Specifically, twenty-one publications, which present systems of indicators for monitoring the sustainable tourism development of destinations have been selected to derive indicators. In the publications, the scope of the study has been presented to clarify theoretical issues and in-depth comments on the most important models. Requirements for the indicators for monitoring sustainable tourism development presented in the publications have been specified with the emphasis on the possibility for providing the necessary information. Specific criteria have been identified on which basis exemplary socio-economic and environmental indicators have been classified in groups. As a result, a system of indicators for monitoring the sustainable tourism development of destinations has been developed and grounded.

Literature Review

Scopes of the Studies Described in the Analyzed Publications

For the present study, 21 publications have been selected that include social, economic, and environmental criteria and indicators for monitoring the sustainable tourism development of destinations. Each publication presents a system of indicators that is applied to the study of sustainable tourism development in a specific area or destination. Thus, the presented systems of social, economic and environmental indicators are suitable for monitoring the sustainable tourism development of a specific destination (e.g., mountain, sea, region, etc.) (*Table 1*).

Requirements for the Indicators

According to their specifics, the destinations can choose the most relevant indicators they wish to adopt and monitor in order to meet the needs of the destinations, the interests of local stakeholders and the specific sustainability issues that the destination faces (*ETIS …, 2016*). The indicators for monitoring sustainable tourism development, which are presented in the analyzed publications were selected according to specific requirements. S. Guerreiro and P. Seguro (*2018*) intended to identify indicators that are considered the most relevant to the field, for which there is available data, and which allow measuring progress. S. Roberts and J. Tribe (*2008*) included indicators that are relevant to the unit of analysis and context and therefore able to promote actions. M. Durovic and S. Lovrentjev (*2014*) tried finding indicators that are sufficient for measuring sustainability in the field and getting reliable data in order to measure and monitor the effects of tourism. According to K. Mearns (*2015*) indicators should summarize relevant information and deliver meaning; and they should provide in-time information to guide the sustainable development of a destination. According to S. Silvera et al. (*2021*) the indicators should be relevant in identifying critical sustainability factors for tourism. A. G. Asmelash and S. Kumar (*2019*) pointed that some of the indicators' selection requirements are relevance to tourism issues and availability of data or feasibility of obtaining and analyzing the needed information. According to M. Lozano-Oyola et al. (*2012*) the selected indicators should be

relevant to sustainable tourism in the target region and to the specific characteristics of a given tourist destination. P. Sobhani et al. (*2022*) stated that indicators are worth selecting considering various requirements, including their relevance, scientific precision, measurability, transparency, adaptability, comparability, efficiency, territorial representation, etc. According to O. M. Ghoochani et al. (*2020*) the most relevant indicators should be selected related to the impact of tourist activities at the destination. M. S. Islam et al. (*2023*) confirm that the indicators should be relevant, feasible, credible, and clear; they should be relevant to the specific area of tourism initiatives. M. Chávez-Cortés and J. A. A. Maya (*2010*) stated that the indicators should provide information on the impact of tourism activities; they should be appropriate and relevant to sustainability. According to A. Gallagher and K. Pike (*2011*) one mechanism by which sustainability can be enabled is through the identification of relevant indicators such that information can be collected and communicated. S. Mutana and G. Mukwada (*2017*) pointed that identifying relevant indicators for a destination is essential; indicators should be useful for measuring and monitoring tourism sustainability. H. He at al. (*2023*) stated that indicators should measure the performance of tourism resources and tourism resource carrying capacity. According to I. Spilanis at al. (*2009*) indicators should be useful to users; they should also be reliable and based on sound scientific concepts; and they should be measurable with data that can be acquired and monitored with reliable procedures. G. Barzekar et al. (*2011*) claimed that indicators should be based on their relevance, analytical soundness, and measurability. A. Reihanian et al. (*2015*) stated that indicators should meet the condition of measurability over time; they need to be understandable and dependent on data that is easily available; they should address the requisites of data availability, credibility, simplicity, and the capacity to show trends over time. T. H. Lee et al. (*2021*) confirmed that indicators should measure the performance of sustainability; they should ensure the reliability of the results. T. Dimoska and B. Petrevska (*2012*) stated that to be useful indicators for sustainable tourism must fulfill the requirements: relevance, availability, meaning, reliability, comparability, etc.; data should be available for the indicators. D. Vagiona and G. Doxopoulos (*2014*) confirmed that for measuring indicators for monitoring sustainable tourism development of destinations, data should be available; indicators should produce desired, comparable results; they should be useful for measuring and monitoring tourism impacts. Thus, it could be summarized that some of the essential requirements for the indicators are their relevance and data ability for measuring sustainable development.

Criteria for the Classification of Indicators

Suitable criteria for classification of socio-economic and environmental indicators for measuring sustainable tourism development of destinations should be selected. The results of literature review reveal that while some authors define criteria of economic, social, and environmental dimensions of sustainable tourism development, others define criteria for overall sustainable tourism development (*Table 2*). Thus, it could be concluded that the specific economic, social, and environmental indicators can be classified in groups according to certain criteria of sustainability.

Sample Indicators for Monitoring Sustainable Tourism Development

The authors of the analyzed scientific publications have identified many indicators for monitoring sustainable tourism development. Below are only some examples of economic, social, and environmental indicators that are presented in the analyzed publications (*Table 3*). The analysis shows that in order a system of indicators for monitoring sustainable tourism to be developed appropriate socio-economic and environmental indicators should be selected and classified according to the chosen criteria. Thus, it could be concluded that on the one hand, the chosen indicators should adhere to specific requirements, such as availability and relevance of the information that they provide, and on the other hand, each indicator should be classified in an appropriate group in order correspondence between indicators and the given criteria to be assured.

Results

Development of a System of Indicators for Monitoring Sustainable Tourism Development of Destinations

Requirements to the Indicators

Indicators for monitoring sustainable tourism development of destinations should reflect aspects such as the characteristics of tourism in general and the characteristics of the destination in particular. They also indicate the available capacity and load on resources. They are a measure of tourism demand and supply, too. Primarily they reveal the social, economic, and environmental benefits realized by the interested parties (visitors, local population, staff, etc.). Thus, it could be summarized that the system for monitoring sustainable tourism development of destinations should include indicators that reveal the key characteristics of tourism development and the specific tourist destinations, the state and sustainable utilization of tourism resources, various aspects of tourism supply and demand, as well as the costs and benefits for the main interested parties.

Below some essential criteria and indicators for monitoring sustainable tourism development of destinations, derived by the analysis of scientific literature are presented. The presented indicators are classified in groups according to the chosen criteria and thus a system of indicators for monitoring sustainable tourism development of destinations is formed. The criteria are selected based on literature review, the specifics of sustainability and the essential characteristics of economic, social, and environmental dimensions of sustainable tourism development, as well as the fundamental theories and statements of tourism studies. The requirements for selecting the indicators for monitoring sustainable tourism development are chosen on the basis of the analysis of the scientific publications that are presented above. The specific requirements for selecting sustainable tourism indicators are relevance, reliance, measurability, availability, and objectivity of the provided information. The selected indicators are related to the economic, social, and environmental aspects of sustainability of tourism destinations. The values of the indicators can be measured regularly because information is available or can be easily obtained from statistical studies, data on the Internet, from social networks, from monitoring through new technologies, at tourism sites, etc. The obtained data is expected to be objective and gathered on a regular basis. Thus, it could be concluded that the

appropriate system for measuring sustainable tourism development of destinations include suitable indicators that both adhere to certain requirement, such as measurability, availability of information, etc. and that correspond to preliminary selected criteria related to social, economic and environmental sustainability of tourism destinations.

Social and Economic Indicators

Social and economic indicators for monitoring sustainable tourism development in destinations are related to aspects, such as the number and satisfaction of visitors and local population, the safety of people in the respective territory, tourism enterprises and number and qualifications of staff, the infrastructure, activities and services that are provided for visitors, the capacity and load on resources, the type and quality of information materials and the content of information provided to tourists, as well as revenues, costs, wages, investments, etc. Socio-economic sustainability indicators should reflect both social and economic benefits and social and economic costs. They should indicate the social benefits for various social groups, especially tourists, local population, and staff, which are related to satisfying their various social needs. These indicators also reflect the economic benefits (revenues, income, etc.) and costs (for materials, wages, investment etc.) for people and especially for resident population and tourism companies and their staff. The social and economic benefits of various social groups are realized due to sustainable tourism development. Socio-economic indicators are closely related to environmental indicators, which reflect the quality of environment, mainly natural environment that is essential for the satisfaction of people and especially visitors. Most social and economic indicators can be used for monitoring the sustainable development of all forms of tourism. Other indicators are suitable for evaluating only some specific forms of tourism, e.g., mountain, sea, cultural and ecotourism, etc. Thus, it could be summarized that socio-economic indicators for sustainable tourism development of destinations reflect social and economic benefits and costs for interested parties (local people, tourists, personnel, etc.).

Below (*Table 4*) are examples of some essential socio-economic indicators that could be used for the assessment of sustainable tourism development of destinations. The indicators have been selected in such a way that, apart from being suitable for the evaluation of the social and economic sustainability of tourism of destinations, their values can be measured because information is available or can be easily obtained from statistical studies, data on the Internet and social networks, ranking of tourism sites, etc. The presented sample indicators have been classified in the following groups: (1) Indicators related to the number of local population and visitors, the ratio between them and the number and satisfaction of visitors and local people who participate in the different activities and use various services within the destinations. These indicators are related to local and tourism demand; (2) Indicators related to the availability, access, quantity and quality of tourism enterprises, infrastructure, sites, activities, products, and services. These indicators are related to supply, including tourism supply; (3) Indicators related to employment and staff in tourism; (4) Indicators related to the information that is provided to visitors; (5) Indicators related to income, revenue, costs, investment, wages, etc. That group include indicators that are measured with currency values. They might be considered as financial indicators. Thus, five groups of socio-economic indicators for measuring social and economic

sustainability of destinations have been distinguished. These indicators are related to tourism supply and demand, costs and revenues.

Environmental Indicators

Environmental indicators for monitoring sustainable tourism development of destinations are related to the capacity and use of natural and physical resources. They indicate the state of natural environment. These indicators reflect the environmental benefits and costs for people that are realized due to sustainable tourism development at destinations. There are general environmental indicators that can be used for monitoring all types of tourism and specific environmental indicators that can be used for monitoring specific types of tourism that are based on natural resources, mainly, nature, mountain, forest, and eco-tourism, etc. Environmental indicators for monitoring sustainable tourism are related to the levels of conservation, protection, reduction of use, consumption, state, quality and pollution of nature and natural resources, such as air, water, energy, land, terrain, soils, flora, and fauna. Thus, it can be summarized that environmental indicators for sustainable tourism development of destinations reflect environmental costs and benefits for stakeholders, such as tourists, local people and the personnel of tourism enterprises.

Environmental indicators for monitoring sustainable tourism development of destinations can be classified in groups according to criteria related to the type and effects on natural resources. Thus, the following criteria for classifying the environmental indicators for monitoring sustainable tourism development are offered: (1) Indicators related to air quality and noise pollution; (2) Indicators related to water quality and consumption; (3) indicators related to energy consumption; (4) indicators related to (solid and liquid) waste management, terrain preservation and soil quality; (5) indicators related to levels and preservation of flora and fauna. Below (Table 5) are some examples of indicators for environmental sustainability of destinations. Thus, five groups of indicators for measuring environmental sustainability of tourism destinations have been distinguished. These indicators are related to the types of and impacts on natural resources.

Discussion

For further studies the following information about the indicators for sustainable tourism development of destinations should be provided. The source of information for each indicator should be specified. The territorial level for which the indicator should be measured should be determined (e.g., global, European, national, regional, local). The type of the destination where the indicator could be applied should be specified (e.g., urban, coastal, rural, mountain). The system of indicators for sustainable tourism development is worth testing at a specific destination. To be applied to that destination it is worth adopting according to the type, size, resources and other characteristics of the destination. The target value of each indicator should be determined. The observation period should be specified. During the observation period monitoring of the achieved values of the indicators for sustainable tourism development of the destination should be performed. The trends in the variation in the values of the indicators should be measured and analyzed as the reasons for the observable trends should be outlined. On that basis, an assessment of the social, economic and environmental, as well as the

overall sustainability of tourism development of the destination should be done. The assessment should be used for improving the system of the indicators for measuring sustainable tourism development of the destination in order to be utilized in the future. Thus, the improved system would be applied to certain destinations.

Conclusion

In that paper a scientifically based and practically applicable system of socio-economic, and ecological indicators for monitoring sustainable tourism development of destinations has been presented. The indicators have been selected based on their relevance to sustainable tourism development of destinations and their measurability due to available or easily obtainable objective, and reliable information. The selected indicators were classified according to developed criteria. The results of the study revealed that socio-economic indicators could be classified in groups according to the following criteria: (1) Indicators related to the number of local population and visitors, the ratio between them and the number and satisfaction of visitors and local people who participate in the various activities and use different services within the destinations. These indicators are related to local and tourism demand; (2) Indicators related to the availability, access, quantity and quality of tourism enterprises, infrastructure, sites, activities, products, and services. These indicators are related to supply, including tourism supply; (3) Indicators related to employment and staff in tourism; (4) Indicators related to the information provided to visitors; (5) Indicators related to income, revenue, costs, investment, wages, etc. That group include economic indicators that are measured with currency values. They might be considered as financial indicators. The environmental indicators could be classified in groups according to the following criteria: (1) Indicators related to air quality and noise pollution; (2) Indicators related to water quality and consumption; (3) indicators related to energy consumption; (4) indicators related to (solid and liquid) waste management, terrain preservation and soil quality; (5) indicators related to levels and preservation of flora and fauna. For each group of socio-cultural and environmental indicators sample indicators for monitoring sustainable tourism development of destinations have been presented, which were chosen based on the outlined requirements (measurability, etc.).

Acknowledgment

This study is financed by the European UnionNextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project № BG-RRP-2.004-0008-C01.

Conflict of Interest

The author declares that there is no conflict of interest.

References:

Asmelash, A. G., & Kumar, S. (2019). Assessing progress of tourism sustainability: Developing and validating sustainability indicators. *Tourism Management*, *71*, 67-83.

Barzekar, G., Aziz, A., Mariapan, M., Ismail, M. H., & Hosseni, S. M. (2011). Delphi technique for generating criteria and indicators in monitoring ecotourism sustainability in Northern forests of

Iran: Case study on Dohezar and Sehezar Watersheds. *Folia Forestalia Polonica. Series A*, *53*(2), 130-141.

Chávez-Cortés, M., & Maya, J. A. A. (2010). Identifying and structuring values to guide the choice of sustainability indicators for tourism development *Sustainability*, *2*, 3074-3099. https://doi.org/10.3390/su2093074

Dimoska, T., & Petrevska, B. (2012). Indicators for sustainable tourism development in Macedonia. *Proceedings of the 1st International Conference on Business, Economics and Finance "From Liberalization to Globalization: Challenges in the Changing World"* (13-15 September), 389-400. Macedonia.

Durovic, M., & Lovrentjev, S. (2014) Indicators of sustainability in cultural tourism. *A multidisciplinary journal of global macro trends. The Macrotheme Review*, *3*(7), 180-189.

ETIS toolkit for sustainable destination management. (2016). The European Tourism Indicator System (ETIS). The European Commission, EU.

Gallagher, A., & Pike, K. (2011). Sustainable management for maritime events and festivals. *Journal of Coastal Research*, *61*, 158-165.

Ghoochani, O. M., Ghanian, M., Khosravipour, B., & Crotts, J. C. (2020). Sustainable tourism development performance in the wetland areas: A proposed composite index. *Tourism Review*, *75*(5), 745-764. https://doi.org/10.1108/TR-02-2019-0061

Guerreiro, S., & Seguro, P. (2018). Sustainable tourism indicators monitoring sustainability performance in the Portuguese tourism industry. *OECD-Eurostat 15th Global Forum on Tourism Statistics*.

He, H., Shen L., Du, X, & Liu, Y. (2023). Analysis of temporal and spatial evolution of tourism resource carrying capacity performance in China. *Ecological Indicators*, *147*, 109951.

Islam, M. S., Lovelock, B., & Coetzee, W. J. L. (2023). Liberating sustainability indicators: developing and implementing a community-operated tourism sustainability indicator system in Boga Lake, Bangladesh. *Journal of Sustainable Tourism*, *31*(7), 1651-1671. https://doi.org/10.1080/09669582.2021.1928147

Lee, T. H., Jan, F. H., & Liu, J. T. (2021). Developing an indicator framework for assessing sustainable tourism: Evidence from a Taiwan ecological resort. *Ecological Indicators*, *125*, 107596.

Lozano-Oyolaa, M., Blancasa, F. J., Gonzalez, M., & Caballerob, R. (2012). Sustainable tourism indicators as planning tools in cultural destinations. *Ecological Indicators*, *18*, 659-675.

Mearns, K. (2015). Applying sustainable tourism indicators to community-based ecotourism ventures in Southern Africa. *Athens Journal of Tourism*, *2*(3), 179-194.

Mutana, S., & Mukwada, G. (2017). An exploratory assessment of significant tourism sustainability indicators for a Montane-based Route in the Drakensberg Mountains. *Sustainability*, *9*, 1202. https://doi.org/10.3390/su9071202

Reihanian, A., Hin, T. W., Kahrom, E., & Mahmood, N. Z. B. (2015). A framework for implementing sustainable tourism in national parks of Iran: Development and use of sustainable tourism indicators in Boujagh National Park, Iran. *Caspian Journal of Environmental Sciences*, *13*(1), 41-52.

Roberts, S., & Tribe, J. (2008). Sustainability indicators for small tourism enterprises – an exploratory perspective. *Journal of Sustainable Tourism*, *16*(5), 575-594. https://doi.org/10.1080/09669580802159644

Silveira, S., Ramos, J., Silva O., & Almeida F. (2021). Sustainability indicators for hospitality SMEs: Application to Portuguese context. *Enlightening Tourism. A Pathmaking Journal*, 11(1), 1-39.

Spilanis, I., Kizos, T., Koulouri, M., Kondyli, J., Vakoufaris, H., & Gatsis, I. (2009). Case study monitoring sustainability in insular areas. *Ecological Indicators*, *9*, 179-187.

Sobhani, P., Esmaeilzadeh, H., Sadeghi, S. M. M., Marcu, M. V., & Wolf, I. D. (2022). Evaluating ecotourism sustainability indicators for protected areas in Tehran, Iran. *Forests*, *13*, 740.

Vagiona, D., & Doxopoulos, G. (2014). Tourism development indicators: the case of Northern Sporades. *Conference Proceedings "Protection and Restoration of the Environment"*, *12*, Thessaloniki.

Appendix

Table 1. Scopes of the studies described in the analyzed publications

Authors, year	Scope or area of study
ETIS, EU, 2016	Involves indicators for sustainable destination management.
Guerreiro&Seguro, 2018	Identified core areas and indicators for monitoring sustainability in the Portuguese tourism industry.
Roberts&Tribe, 2008	Identified themes and indicators for monitoring the sustainability of small tourism enterprises.
Durovic&Lovrentjev, 2014	Formed a group of indicators according to the main aspects of the dimensions of sustainable tourism for measuring sustainability of cultural tourism.
Mearns, 2015	Applied sustainable tourism indicators to community-based ecotourism ventures in South Africa.
Silvera et al., 2021	Identified sustainability indicators for Portuguese hospitality SMEs.
Asmelash&Kumar, 2019	Developed and tested a set of indicators for assessment of the progress towards sustainable tourism development.
Lozano-Oyola et al., 2012	Presented indicator system to evaluate sustainable tourism at cultural destinations.
Sobhani et al., 2022	Evaluated indicators for protected areas in Tehran, Iran.
Ghoochani et al., 2020	Identified indicators for measuring sustainable tourism development in the wetland areas.
Islam et al., 2023	Developed and implemented a community operated tourism sustainability indicator system in Boga Lake, Bangladesh.
Chavez-Cortes&Maya, 2010	Identified sustainability indicators for tourism development at a local level in a Mexican community.
Gallagher&Pike, 2011	Developed a suite of indicators, which can be used by the events management industry to describe their sustainable practice.
Mutana&Mukwada, 2017	Assessed significant tourism sustainability indicators for a Montane-Based Rout in the Drakensberg Mountain, South Africa.
He at al., 2023	Used indicators to measure tourism resource carrying capacity performance in China.
Spilanis at al., 2009	Used indicators for estimation of the sustainability at the island level.
Barzekar et al., 2011	Generated indicators for monitoring ecotourism sustainability in Northern forests of Iran.
Reihanian et al., 2015	Developed and used sustainable tourism indicators in Boujagh National Park, Iran.
Lee et al., 2021	Developed an indicator framework for assessing sustainable tourism at a Taiwan ecological resort.
Dimoska&Petrevska, 2012	Estimated sustainable tourism development indicators in Macedonia.
Vagiona&Doxopoulos, 2014	Identified and implemented a set of tourism indicators for the Regional Unit of Northern Sporades in order to upgrade tourism development.

Table 2. Core criteria for classifying indicators for monitoring sustainable tourism development

Authors, year	Criteria
ETIS, EU, 2016	Economic dimension Tourism flow at destinations, tourism enterprises performance, quantity and quality of employment, tourism supply chain
	Social dimension Community/ social impact, health and safety, gender equality, inclusion/ accessibility, protecting and enhancing cultural heritage, local identity, and assets
	Environmental dimension Reducing transport impact, climate change, solid waste management, sewage treatment, water management, energy usage, landscape, and biodiversity protection
	Others-Destination management Sustainable tourism public policy, customer satisfaction
Guerreiro&Seguro, 2018 (following	Economic dimension Seasonality, economic benefits, employment
	Social dimension

UNWTO guidelines, 2004,2016,2017)	Tourist satisfaction, local satisfaction, pressure, accessibility
	Environmental dimension Environmental management, energy management, solid waste management
Roberts&Tribe, 2008 (largely drown form WTO Indicator Frameworks, 2000)	Economic dimension Business/ performance profitability, foreign exchange leakage and domestic leakages, employment, quality of employment, business motivation
	Social dimension Community involvement, resident access, host relations to tourists, crime and harassment, cultural promotion, ownership patterns
	Environmental dimension Environmental awareness and management, energy efficiency, water efficiency and monitoring, recycling and reuse, solid waste management, wastewater management, pollution effects management, visual pollution
	Others - Management/ institutional sustainability indicators Management and staff training, access to finance
Durovic&Lovrentjev, 2014	Economic dimension Economic benefits of cultural tourism for the host community and destination, sustaining tourist satisfaction, cultural facilities, institutional regulation, seasonality of tourism activity, tourism related transport, cultural routes
	Social dimension Socio-cultural effects of tourism on host community, local public safety, conservation of cultural heritage, social carrying capacity of the destination, safeguarding cultural identity and local community, quality of life in general
	Environmental dimension Protection of the natural ecosystem, energy management, water availability and management, wastewater treatment, waste management, atmospheric pollution, management of the visual impact of facilities and infrastructure, intensity of use, environmental management
Mearns, 2015 (WTO, 2004 and author's estimation)	Economic dimension Sustainable tourism satisfaction, tourism seasonality, economic benefits of tourism
	Social dimension Local satisfaction with tourism, effects with tourism on communities, education, community decision-making, community benefits, culture
	Environmental dimension Energy management, water availability and conservation, drinking water quality, sewage treatment, solid waste management, controlling use intensity, biodiversity, and conservation
	Others - Crosscutting issues Development controls, networking, and collaboration
Silvera et al., 2021 (ETIS, WTO)	Economic dimension Seasonality, transport, economic benefits, tourist satisfaction level, employment
	Social dimension Satisfaction, pressure, accessibility, effect of tourism on the community, conservation of cultural heritage, quality of life
	Environmental dimension Environmental management, energy management, solid waste management, water management, protection of the natural ecosystem, impact on the environment, conservation of biodiversity and landscapes, resource conservation
	Others - Management Management system, local planning
Asmelash&Kumar, 2019	Economic dimension Employment quality, economic viability, local prosperity
	Social dimension Social equity, visitor fulfillment, local control, community wellbeing, cultural richness
	Environmental dimension Physical integrity, biological diversity, resources efficiency, environmental purity
	Others - Institutional sustainability Local-oriented control policy, political participation, local planning policy, political support at different levels of governments
	Economic dimension

Lozano-Oyola et al., 2012	Economic benefits of tourism for the host community and destination, sustaining tourist satisfaction, development control, tourism facilities on offer – provision of a variety of experiences, seasonality of tourism activity, tourism employment, tourism-related transport, destination competitiveness, tourist routes, cultural investment, agglomeration
	Social dimension Socio-cultural effects of tourism on host community, local public safety, conservation of cultural heritage, effect on local population structure, social carrying capacity of the destination, effect on level of well-being of the local population, improvement of the urban landscape
	Environmental dimension Protection of the natural ecosystems, energy management, water availability and management, wastewater treatment, management of solid urban waste, atmospheric pollution, management of the visual impact of facilities and infrastructure, intensity of use, environmental management
Sobhani et al., 2022	Economic dimension Information and communication infrastructure, local prices, employment, governmental and non-governmental institutions, government investments, monitoring and control, institutional co-operation, quality of managerial functions, ecotourism costs, rules and regulations
	Social dimension Satisfaction, participation, feeling of security, population density, culture, justice
	Environmental dimension Environmental pollution, ecosystems, biodiversity, ecotourism carrying capacity, safety, ecotourism infrastructure and facilities
Ghoochani et al., 2020	Economic dimension Dependency of income of households around the wetland on tourism, gender equality, business enterprises related to tourism, hard tourism infrastructure, branding, investment volume, the diversity of income sources, willingness to pay
	Social dimension Social capital, psychological, local community participation in the development of wetland tourism, soft infrastructure related to tourism, cultural exchange, population, satisfaction of tourism development
	Environmental dimension Systematic introducing of wetlands, attitude toward environmental protection, ambient quality, biodiversity, environmental NGOs, tourism diversity, protective value of wetland, land-use change
Islam et al., 2023	Economic dimension Economic growth of tourism, contribution of household income and standard of living
	Social dimension Tourism satisfaction, social cohesion affected by tourism, local satisfaction about tourism, whether the culture being degraded or lost, potentials for preserving culture and traditions
	Environmental dimension Quality of the water of the Boga Lake, preservation of flora, preservation of fauna, preservation of natural beauty and minimizing visual pollution
	Others - Local government/ political dimension Supportive roles of local government, negative roles of local government, committee of the local community for community-based tourism development and maintenance
Chavez-Cortes&Maya, 2010	Economic dimension Jumpstart regional development, reposition the Integrally Planned Centers Bahias de Huatulco, improve agricultural activity
	Social dimension Improve life standards of the population, make easier the incorporation of local people in tourism activity, defend current agricultural land-use
	Environmental dimension Conserve ecosystem goods and services, prevent and control environmental impacts
	Political/ institutional

	Improve institutional response from the National Trust for Tourism Promotion of Mexico
Gallagher&Pike, 2011	Economic dimension Supporting sustainability
	Social dimension Community engagement and participation, education and awareness, procurement and employment, significance, and recognition
	Environmental dimension Energy, materials and waste, water and sewage, transport, environmental actions
Authors, year	Criteria
Mutana&Mukwada, 2017	Effective sustainable management, social and economic benefits to local community, benefits to cultural heritage, benefits to the environment
He at al., 2023	Tourism economic load, tourism social load, tourism ecological load, tourism attraction resource, tourism service resource, tourism ecological resource
Spilanis at al., 2009	Employment, exports, economic performance of enterprises, product, active population, unemployed, job position, income, population, biodiversity, land-use types, water quality and quantity, soil quality and quantity, urban environment
Barzekar et al., 2011	Conservation of natural resources and biodiversity, educational affairs and public awareness, maintenance of soil and water resources, tourists and local people satisfaction, economic benefits and poverty alleviation, maintenance of heritage and cultural diversity, maintenance of scenery, natural and physical feature, maintenance of hygiene and tourist safety, existence of legal, institution, legislation, and policy
Reihanian et al., 2015	Visitors' satisfaction with their experiences, regional development (economy), visitors' awareness (environment), local community awareness (society), local community participation in the planning process (management)
Lee et al., 2021	Environmental management, economic management, socio-cultural management, government policy, human resource management, science, and technology
Dimoska&Petrevska, 2012 (UNWTO, 2004)	Local satisfaction effect of tourism on communities, sustaining tourist satisfaction, tourism seasonality, economic benefits of tourism, energy management, water availability and conservation, drinking water quality, sewage treatment, solid waste management, development control, controlling use intensity
Vagiona&Doxopoulos, 2014	Population, health, transport, tourist services, coasting, accommodation, geographical features, land uses, biodiversity, energy, water wastes, bathing water quality

Table 3. Sample indicators for monitoring sustainable tourism development that are presented in scientific literature

Authors, year	Sample indicators
ETIS, EU, 2016	Percentage of tourism enterprises using voluntary certification, number of tourist nights per month, relative contribution of tourism to the destination's economy (%GDP), daily spending per overnight tourist, average length of stay of tourists, occupancy rate of commercial accommodation, direct tourism employment as a percentage of total employment, percentage of jobs in tourism that are seasonal, percentage of locally produced food, drinks, goods and services, number of tourists per 100 residents, number of beds available in commercial accommodation establishments per 100 residents, percentage of the destination's events that are focused on traditional culture and heritage, percentage of tourists using different modes of transport, percentage of tourism enterprises separating different types of waste, percentage of tourism enterprises taking actions to reduce water consumption, percentage of tourism enterprises taking actions to reduce energy consumption, percentage of annual amount of energy consumed from renewable sources compared to overall energy consumption, percentage of local enterprises in the tourism sector actively supporting protection of local biodiversity and landscapes, etc.
Guerreiro&Seguro, 2018	Number of tourists, percentage of jobs that are seasonal, percentage of excellent or good water quality, direct energy consumption, etc.
Roberts&Tribe, 2008	Employee salaries, percent of locals employed, energy consumption, water consumption, energy conservation measures, water conservation measures, etc.

Durovic&Lovrentjev, 2014	Capacity of transport services, employment generated by the service sector, investment in the service sector, noise pollution, etc.
Mearns, 2015	Education of tourists, training of staff, revenue generated, waste volume produced, number of tourists per square meter of the site, etc.
Silvera et al., 2021	Number of beds, protection of natural assets, expenditure on the environment, percentage of certified facilities, protection of historical sites, etc.
Asmelash&Kumar, 2019	Variety of local products, income to the local community, pressure of tourist activities on fauna and flora species, host-guest interaction, number of additional services, etc.
Lozano-Oyola et al., 2012	Capacity of services, heritage interpretation, tourist routes created, promotion of activities for tourism, volume of tourism employment, etc.
Sobhani et al., 2022	Access to information, access to tourism attractions, access to restaurants, access to accommodation, access to tour agencies, etc.
Ghoochani et al., 2020	Number of businesses related to tourism, number of attractions, public sector investment volume, private sector investment volume, etc.
Islam et al., 2023	Ensuring tourist safety and security, promoting the destination to tourists, number of cultural festivals at the area in a certain period of time, etc.
Chavez-Cortes&Maya, 2010	Number of certified local employees, amount of investment for local personnel training, number of rooms, air quality, endangered, rare species, etc.
Gallagher&Pike, 2011	Carbon offsetting initiatives, environmental conservation initiatives, educational initiatives related to sustainability, waste generation and disposal, etc.
Mutana&Mukwada, 2017	Protecting cultural heritage, presenting culture and heritage, conserving resources, reducing pollution, information, and interpretation, etc.
He at al., 2023	Proportion of domestic tourists to residents, proportion of international tourists to residents, number of intangible cultural heritage per local people, etc.
Spilanis at al., 2009	New enterprises, seasonal workers per employed, protected area per total area, quality of drinking and irrigation water, quality of bathing water, etc.
Barzekar et al., 2011	Diversity of plants and wildlife, number of educational workshops, number of information centers, number of brochures, etc.
Reihanian et al., 2015	Proportion of local community involvement in tourism development, proportion of visitor awareness of conservation regulations, etc.
Lee et al., 2021	The resort provides signs to remind customers when to save resources, environmental friendliness of accommodation, existence of website, etc.
Dimoska&Petrevska, 2012	Number of tourist industry jobs, which are permanent, revenues generated by tourism as a percentage of total revenue, etc.
Vagiona&Doxopoulos, 2014	Peak season tourists to local population, number of visitors per 1 m coastline, peak season energy consumption to off-season energy consumption, etc.

Table 4. Classification and sample social and economic indicators for monitoring sustainable tourism development in destinations

Criteria	Sample social and economic indicators
Indicators related to the number of local population and visitors, the ratio between them and number and the satisfaction of visitors and local people who participate in the various activities and use different services within the destinations	Number of local people, number of tourists, number of tourists to local people, domestic tourists to local people, international tourists to local people, number of arrivals at accommodation establishments, number of arrivals at accommodation establishments to local people, number of tourists per square meter, number of arrivals at accommodation establishment per square meter, number of tourists per square meter in key sites, number of tourists in peak months and average for the year, number of tourists participating in different types of activities, number of overnight stays, number of tourist nights per month, number of tourists per night, average length of stay of tourists in days, occupancy rate of accommodation establishments, number of nights spent at accommodation relative to number of local population, number of nights spent at accommodation relative to the area of the region, satisfaction of tourists (measured by their ratings for tourist sites, activities and services on social networks, websites, etc.), number of local people who can communicate with foreign tourists, level of participation of local people

	and tourists in different types of activities and using the various types services, level of participation in joint initiatives and activities of tourists and local population, etc.
Indicators related to the availability, access, quantity and quality of tourism enterprises, infrastructure, sites, activities, products, and services	Availability of cultural and historical heritage sites, availability of sport facilities, number of local enterprises, percentage of tourism enterprises/ establishments in the destination using a voluntary environmental certification, state and attractiveness of tourism sites, number and quality of recreational facilities and possible activities, provision of local products, amount of local production for sale to tourists, access to cultural and natural tourism attractions, use of green design technology, community activities that foster collective learning, volume of traffic, availability of environment-friendly economic activities, number and quality of restaurants facilities and services, number and quality of accommodation establishments and services, access to emergency services, access to fire services, access to health services, access to garbage containers, number of tour agencies, availability of activities related to protection of nature, and cultural and historical monuments, activities related to supporting arts, culture and handicrafts, state of tourism infrastructure, variety of local services, availability of local events, number of joint initiatives and activities of tourists and local population, number of initiatives involving tourists in environmental protection and cleaning, availability of initiatives involving tourists in supporting local socio-economic development of the destination, number of beds in accommodation in relation to local population, number of bed places relative to the total area of the region, etc.
Indicators related to employment and staff in tourism	Number of employed in tourism sector, number of employees in tourism in relation to the total number employed, number of employees in tourism to the number of local population, percentage of fulltime jobs in tourism, retention level of employees in tourism, number of qualified/ certified employees, number of employed in accommodation and food establishments, number of employed in travel agencies, number of employed at tourist attractions, number of educated and trained local people, formation of apprenticeship training positions, number of employees of local population, quality performance of managers, quality performance of local tour guides, quality performance of environmental guardians, number of people who are engaged in craft art production, number of local people who exercise traditions, number of people who provide local products, etc.
Indicators related to the information provided to visitors	Availability, access and number of information centers, tourist information offices, travel review sites, historical archives and records, educational facilities and workshops, etc., access, availability and quality of information in travel guides, informational and advertising materials, the Internet, at the sites, on signs and signage and signage boards, brochures and banners, etc., access to maps, number of brochures for representing attraction areas and biodiversity, education of nature protection in local educational center, documentation of indigenous knowledge, nature interpretation center and visitor facilities, signage of wild life and fauna, etc.
Indicators related to income, revenue, costs, investment, wages, etc.	The share of tourism in GDP, tourism revenue per year, income per capita, average spending per visitor, daily spending per overnight tourist (accommodation, food and drinks, other services), tourism expenditures on museums, entertainment and excursions, training funds spent per employee, share of foreign and local capital investment, level of wages in tourism, in hotel and restaurant sector, in travel agencies and attractions, etc., wage level of local residents, expenditure for access to tourism area, amount of local revenue from tourism, income of local households, income from services such as fishing, harvesting and recreation, level of government financial support; amount of investment in tourism, prices and costs of food, accommodation, transportation, commodities, health services, etc., cost of using local facilities, etc.

Table 5. Classification and sample environmental indicators for monitoring sustainable tourism development in destinations

Criteria	Sample environmental indicators
Indicators related to air quality and noise pollution	Air quality, air pollution, noise pollution, level of carbon emissions, level of carbon emission reduction, monitoring air quality, measures taken for carbon emission reduction, etc.

Indicators related to water quality and consumption	Water consumption, water pollution, level of water reduction, measures taken for water use reduction, conservation of water, monitoring water, quality of water, quality of drinking water, quality of irrigation water, quality of bathing water, etc.
Indicators related to energy consumption	Energy consumption, energy reduction, measures taken for energy reduction, energy consumed from green energy sources, etc.
Indicators related to (solid and liquid) waste management, terrain preservation and soil quality	Waste volume generated, waste disposal, monitoring waste levels, sewage treatment, waste recycled, percentage of tourism enterprises separating different types of waste, etc.
Indicators related to levels and preservation of flora and fauna	Flora and fauna protection, percentage of local tourism enterprises supporting measure for protection of local flora and fauna, diversity of flora and fauna, rare animals, and plants, etc.

Bakhtin, M. V. [a][*]

SUBJECTS OF SOCIAL MEMORY AND THE TRANSMISSION OF HISTORICITY [*]

Abstract: In the context of the fragmentation of historical perception and the deformation of subjectivity, issues concerning the integrity of historical experience, the transmission of collective identity, and the prognostic functions of historical imagination become particularly relevant. The study subject is the semantic, categorical, and functional aspects of the imaginary as an epistemological phenomenon within historical knowledge, its connection to social memory, subjectivity, and the dialogical structure of the historical process. The study object is the epistemology of history as a distinct field of philosophical inquiry, within which interrelations between historical imagination, social forms of memory, symbolic structures of culture, and the subject of historical action are explored. The study aims to analyse and provide a philosophical and epistemological justification for the role of the imaginary and social memory in shaping a coherent historical consciousness and in the reproduction of historical subjectivity. To achieve the aim and address the set objectives, the study employs a range of scholarly methods, including the hermeneutic method, phenomenological analysis, the epistemological approach, cultural-historical analysis, the comparative-historical method, and the method of critical reflection. The study draws on the works of European, American, and Russian scholars in philosophy. The author examines the interrelations between epistemological discourse and historical subjectivity, identifies the place and role of social memory in this process, and demonstrates that social memory serves as a means of forming the social organism and educational processes. An attempt is made to comprehend the unity of the past, present, and future within a unifying concept of the logical and procedural organisation of history.

Keywords: epistemologiya of the history, subjects of history, social memory, archetypes, collective unconscious, symbols.

Introduction

Contemporary philosophical and historical-epistemological thought is undergoing an intensive turn towards the study of symbolic forms, the imaginary, and social memory as key mediators of cultural-historical consciousness. In the context of fragmented historical perception and the deformation of subjectivity, issues concerning the integrity of historical experience, the processes of transmitting collective identity, and the prognostic functions of historical imagination become particularly pertinent.

The phenomenon of the imaginary, considered within the logical and procedural organisation of history, represents both a heuristic resource and a mode of philosophical articulation of the meanings of historical existence, as well as a means of overcoming the epistemological crises of modern culture.

The study subject comprises the semantic, categorical, and functional aspects of the imaginary as an epistemological phenomenon within historical knowledge, its connection to social memory, subjectivity, and the dialogical structure of the historical process.

The study object is the epistemology of history as a distinct domain of philosophical knowledge, within which the interrelations between historical imagination, social forms of memory, symbolic structures of culture, and the subject of historical action are examined.

[a] Maksim V. Bakhtin, Professor, Doctor of Philosophical Sciences, International Business Professors Club. Ragusa, Italy. ORCID 0000-0003-1366-3009. E-mail: dr.maximebakhtin@gmail.com

The study aims to analyse and provide a philosophical-epistemological justification for the role of the imaginary and social memory in shaping a coherent historical consciousness and the reproduction of historical subjectivity.

Based on the purpose, the following study objectives have been formulated:

- identify the epistemological foundations of the problem of the imaginary in history;
- describe the functions and forms of social memory as the basis of collective identity;
- explore the relationship between the historical subject, memory, and symbolic imagination;
- analyse the significance of symbol and dialogue in the reproduction of historical experience;
- investigate the potential of the imaginary in the context of forecasting "possible worlds" of history;
- justify the necessity of a coherent epistemological discourse as a counterbalance to the fragmented perception of historical reality;
- trace the transformations of historical subjectivity under the conditions of mass culture and informational influence.

Methods and Materials

To achieve the purpose of the study and address the objectives set, several scholarly methods were employed, including the hermeneutic method, which enables the interpretation of texts and symbolic forms within the context of historical tradition and cultural memory; phenomenological analysis, aimed at identifying the subjective experience of history and the formation of the imagined image of the world; the epistemological approach, focused on reconstructing the modes of historical knowledge and understanding; cultural-historical analysis, which allows for the uncovering of mechanisms for the transmission of meanings and forms of identity in historical consciousness; the comparative-historical method, used to analyse changes in the understanding of subjectivity and memory across different historical periods; and the method of critical reflection, directed at identifying ruptures, distortions, and potential pathways of integration within historical epistemology.

The study drew upon the works of notable European and American researchers in philosophy.

Dutch philosopher F.R. Ankersmit's work is devoted to the study of the role of metaphor and rhetoric in historical knowledge. He offers an original approach to historiography, treating narrative as a constitutive element of historical meaning. His book is crucial for understanding the tropological turn in the philosophy of history and the issues of representing the past.

The work *The Epochs of Interpretation* presents the philosophical views of Gianni Vattimo on historicity as interpretation and the notion of "weak thought". The author critiques the idea of a single truth, emphasising the multiplicity of narratives. This text is important for shaping the postmodernist approach to the epistemology of history and social memory.

In her book *Philosophy of History After Postmodernism*, Ewa Domańska explores the main directions in the development of the philosophy of history following the so-called "linguistic turn". The author highlights the importance of the ethical dimension of historical knowledge and the reconsideration of traditional explanatory models. This work serves as a key reference point for contemporary critical historiography.

In the seminal work *The Imaginary Institution of Society*, Cornelius Castoriadis introduces the concept of the "social imaginary" as the foundation of society's historical and cultural self-organisation. His work provides a productive theoretical tool for analysing collective memory and the symbolic structures of society.

In the course of the study, certain works by Russian scholars were also utilised.

In his monograph *The Meaning of the Possible: Connotative Semantics*, S.S. Gusev explores the principles of connotative analysis and the potential of semantics as a tool for uncovering latent meanings in texts and social narratives. The book is particularly significant for studies concerning the reconstruction of historical meanings and cultural memory.

A.I. Makarov's study *The Phenomenon of Supra-Individual Memory: Image—Concept—Identity* is devoted to the phenomenon of collective memory as a supra-individual form of cultural identity. The author analyses the interaction between image, concept, and the social construct of memory, making the work highly relevant to the epistemology of historical consciousness.

The article by L.V. Balakhonskaya and V.V. Balakhonsky *Societal Security: Historical-Philosophical and Theoretical Aspects of Understanding* examines the concepts of security through the lens of historical-philosophical analysis, with an emphasis on the dynamics of social perceptions of risk, control, and stability. This work brings to the fore the philosophical interpretation of historical experience as a source of social regulation.

A.A. Gryakalov's succinct and insightful article *Night in Broad Daylight: Towards a Hermeneutics of Subjectivity* offers a hermeneutic analysis of subjective experience in the context of cultural memory. The author regards subjectivity as an epistemological dimension essential to the reconstruction of the meanings of the past in contemporary interpretive practice.

N.S. Mudragey's article *The Middle Ages and Scientific Thought* provides an overview of approaches to scientific knowledge during the medieval period, demonstrating how the religious-symbolic system shaped the epistemological boundaries of understanding. The work is valuable for a retrospective analysis of paradigms of historical thinking.

Results

The epistemology of history represents the correlation of actual social processes, despite the diversity of their interpretation and the theoretical logic of historicity. Within this field of interactions, social memory serves as a special "meeting place" (*Vattimo & Rorty, 2005, p. 219*). The relationship between epistemological discourse and historical subjectivity is complex and contradictory, particularly in regard to the loss, removal, or dispersion of the subject. Social memory becomes the focal point for the restoration of the subject and subjectivity—it is here that collective experiences of history intersect with the epistemological reflection on history. What is at stake is a holistic form of collective memory that enables the formation of individual destiny, just as existing within history provides the means for the socialisation of the individual in and through history.

When addressing this issue, it is essential to consider the experience of theoretical reflection on history. One must pay particular attention to the fact that the themes of the image of the human being and their historical world are initially embedded in cosmological ideas, in which the concept of life far exceeds the life of the individual in both duration and complexity. Accordingly, collective memory—defined in other "formats" as social or supra-individual—

enables thought to unfold within a mode of continuity: the past, present, and future converge within a unifying concept of the logical-processual structure of history. In this sense, memory operates not only as an epistemological tool, a means of understanding reality, but also as an ontological value of existence. F.R. Ankersmit quite rightly speaks of a radical change in the "epistemological rules of historiography", even of the destruction of traditional epistemological standards: "This is what could be called the psychoanalysis of science and scientific practice." (*Ankersmit, 1994, p. 315*)

Moreover, the virtual aspect of the epistemology of history must also be taken into account. The highly complex question of the socio-historical has long eluded traditional philosophy of history precisely because it tended to reduce the significance of imagination and the imaginary. It is therefore more appropriate to assert that the problematic of the imaginary within the logical-processual organisation of history constitutes an essential component of the contemporary worldview, acting as a fundamental guide in the search for temporal meaning. It emerges as a particular kind of phenomenon that integrates creativity, freedom, value orientations, and a theme particularly significant in Russian thought: that of "cosmic projection". One could say that the imaginary constitutes a point of convergence for the most vital intellectual quests in Russian philosophy—thus becoming a kind of synthesis or event of thought that can be considered in the present context of contemporary inquiry.

It is important to reflect on the semantic configuration that the imaginary may structure within the realm of social memory: "we are faced with the question of the possibility of humanity—and humanity as possibility" (*Gusev, 2003, p. 361*). This calls for an investigation into the semantic and categorical status, the functions and contemporary understanding of the imaginary, as well as the origins and historical development of the image and the concept of the imaginary as a distinct socio-cultural phenomenon. Such an approach corresponds closely to the intentions of contemporary philosophy and the epistemology of history to comprehend the states of cultural-historical consciousness, mentalities, and the facts of everyday life. The imaginary indicates ways of shaping a prognostically oriented philosophical vision of the human being, which, in the current climate of heightened interest in the virtual worlds of "future history", social imaginaries, and possible worlds and communities, is both timely and in demand.

The phenomenon of the imaginary opens up possibilities for a sustainable understanding of both culture and the human being, counteracting the fragmentary representations of postmodernism concerning the human subject and history. The imaginary correlates directly with the "history of mentalities", restoring at the level of ideal images and representations the order of collective existence. In this respect, the imaginary is directly related to the problem of archetypes, the collective unconscious, and may be integrated into the current context of forecasting the strategies of "possible worlds" in history.

The aforementioned reflections on the imaginary and the virtual in the interpretation of the processual logic of historicity are particularly significant in that they entail the definition of the "possible future". Projecting the present onto the future enables an assessment of the viability of the potentialities already discovered by human reason (*Gusev, 2003, p. 369*). One might say that the phenomenon of imagination connects educational paradigms across time, remaining a stable constant in the human endeavour to construct a meaningful existence.

If we proceed from the assumption that the ancient cosmos implied a corporeal and plastic embodiment of human history, as A.F. Losev argued, then memory becomes the means through which the social organism and processes of education are formed. Memory contains the semantic core of tradition, a constant of meaning for the entire body of texts within a given culture. This core is composed of symbols of group identity which, beyond their role in ensuring socialisation, serve to orient members of a civilisational collective within the semantic space of that cultural community. Should these symbols lose their capacity to perform such functions, it results in the disintegration of the systems of historical and cultural orientation.

In the epistemology of history, texts that are aligned with the semantic invariant of culture prevail; this invariant allows a culture to maintain its self-identity despite the variability of interpretations. Y.M. Lotman noted that the mechanisms of societal disintegration are set in motion when a rupture occurs between cultural memory and the synchronous mechanisms of text production. In his description of a "cultural explosion", Lotman raised the issue of historical moments when a "gap of being" appears—through the world of established meanings, the "ultimate reality" of the world image begins to shine through. It is precisely this *manifestation* that makes it possible to speak of the experience of a holistic image of the world—only through such revelations can interest in the processual logic of history acquire a truly personal, responsible attitude towards the world.

The conduits to the repositories of memory are specific symbolic images. In this sense, a symbol may be defined as an image that has exceeded its boundaries; the unveiling of a true image is, in fact, an act of philosophical inquiry. However, the problem of the truth of the image of history inevitably arises.

Today, the fallacy of "discrete" historical consciousness has become evident—that is, the tendency to focus on isolated fragments of the world image. One might speak of a topological turn in the epistemology of history. In the real process of history, and accordingly in its logical comprehension, irreconcilable elements become apparent: continuity and discontinuity, richness and poverty, the familiar and the alien. When attention is focused solely on fragments of epistemology or the experience of historical processes, a holistic representation becomes utterly impossible, due to the absence of a unified field of explanation and understanding. Ultimately, this results in a phenomenon akin to "social autism" or even "social schizophrenia"—an inability to explain or comprehend the coexistence of various worlds of values and meanings.

In the dialogic epistemology of history, it is precisely dialogue that must be actualised—for it is here that social memory and the real processes of "life knowledge" encounter one another. In Russian historiosophy, the personal is necessarily correlated with the impersonal and the supra-personal as forms of transcendence. The experience of history and its meaning are mutually redefined in an existential act of vision—this points to the theme of meaningful and responsible engagement with the world, which transcends concrete historicity.

It should also be taken into account that real processes of socialisation form a special kind of social sensitivity, attuned to the enchantment with the fragmentary and the episodic. Such enchantment obstructs engagement with the whole—an overarching historical narrative—obscures the vision of the whole and impedes the assessment of events in terms of their embeddedness within the broader historical perspective. In this case, a unified epistemological

discourse of history is absent—it becomes dispersed, while simultaneously recorded across both proximate and distant spheres of practical activity—in politics, economics, religion and religious studies, ethno-cultural relations, art, power structures, and the interpretation of alienation and social autism.

Thus, in a situation of discreteness and fragmentation, the very value of tradition is called into question—contemporaries perceive only intense fragments. Against this background, it is the socio-philosophical approach that has the capacity to construct a coherent "logic of history", which in turn makes it possible to represent a fragmented world as an "epistemologically balanced" semantic unity. The historical materiality that is present is revealed in the epistemological discourse: the positions of historical knowledge are "object-based and corporeal" in the sense of their real existence within the historical process. This is precisely how an image of contemporary epistemology of history is shaped—one where there is no single standard, but there are dialogical strategies for defining the "unity of multiplicity" within current configurations of modernity.

The notion of "historical accord" among humanity existed during the Enlightenment era—it was what was termed the "universal model of culture". Today, however, the focus of the epistemology of history has shifted towards mechanisms that are not so much universal and cultural, as discursive and socio-anthropological. What is required is the analysis not only of significant symbols—"gestures of life", spatial imagery, the organisation of material environments and everyday life—but also of the epistemology of history's paradigms and discourses. Contemporary discursive models possess meaning-generating energy no less potent than the categories of speculative philosophy of history.

Equally important is the fact that individual consciousness is now far more intensely connected to the sphere of collective experience than in the past—an individual's survival depends upon collective knowledge. Conversely, the formation and self-preservation of social organisms are made possible through their connection to specific supra-individual structures of consciousness. The key concept here is that of the socio-historical environment, defined as an immense set of contexts external to the human psyche. This includes the sphere of social relations, the realm of symbolic cultural forms, and supra-individual consciousness structures.

The essential premise in the matter of transmitting social experience is that experience is not given "in and of itself"—human experience is dependent upon the organisation of the exchange of personal experience, the processing of information, the combination and recombination of images, the preservation of information and its transmission from generation to generation. This transmission takes place through channels of social communication—foremost among them being the symbolic medium of culture. History may be understood as a network of symbols interwoven around the human being—emerging through the social interaction of meanings and actions.

A person encounters reality, leaving behind a "trace-image"—in the course of action, these traces are reflected upon; thought exists in dialogue as an image of memory. The fusion in consciousness of a meaningful image and a material thing produces a symbol, which points towards a possible world. The distinctiveness of human thought and consciousness lies in the fact that symbolic forms possess both a virtual aspect (meanings) and a material one (carriers of meaning).

Meanings may be fixed and preserved over time through two different mechanisms: within individual consciousness as a system of associations grounded in biographical memory, and within social consciousness in the form of material cultural artefacts. Through systems of codes, particular forms of life activity are transmitted through space and time. Collective and supra-individual forms of organising historical experience are indispensable precisely because the individual alone cannot ensure their survival. One may therefore argue that the basic survival of the human being presupposes the existence of such phenomena as compensate for the lack of genetic information. Information about appropriate behaviour within an environment is obtained through the synthesis of past and present experience and necessarily requires an orientation towards the possible—often defined virtually—future.

It is precisely the "universal dimension of memory" or "supra-individual memory" that enables the transmission of worldview-related knowledge and the principles of collective identity from one generation to the next. The symbolic sphere of communication plays a particularly important role here, as within it the subjects of social memory "construct themselves into the sphere"—the heuristic aspects of dialogue act as programmes of socio-cultural action and converge with education in performing the function of foresight: ensuring the agency of the collective in the future through the transmission of socially significant information to younger generations and teaching them the "technologies of survival".

At the same time, the communicative function of the symbol enables people to engage in interaction and helps to create a specific communicative space. It possesses both psychological and sign-symbolic dimensions. The psychological aspect of communication generates emotional resonance aimed at uniting the collective and contributes to the formation of individual and collective identities. The sign-symbolic aspect functions as a sort of "language of the collective". This is manifested through the transmission of information via speech, sound expression, and material-symbolic representation. In this sense, the symbol accumulates both social and individual experience—i.e., social memory.

The compensatory function of the symbol is closely related to the nature of cultural dialogue in the sense that dialogue may act as a special dimension of historical existence, through which social alienation can be overcome. In this context, frustration and alienation may be resolved by compensating for a lack of social experience in spiritual culture. At the same time, there is the possibility of so-called illusory compensatory fulfilment—most often and traditionally realised within the framework of religious experience and the arts. The regulative and value-oriented functions of the "dialogue of history" serve as models, norms, and rules of action in real-life situations—dialogue appears as an ideal form of relation and a particular kind of cultural constant. These include various types of prohibitions: moral, legal, and religious. In primitive societies, systems of social prohibition took the form of taboos.

This typology can ultimately be reduced to the core idea of dialogue: its socio-cultural function is to preserve and transmit meaning and socially significant information. One may thus speak of the artistic-aesthetic aspect of the epistemology of history ("the aesthetics of history"), which manifests as the form and emotional experience of historical activity; the pedagogical aspect, realised through the cultivation of particular personal qualities within a framework of "social demand"; the ideological aspect, which takes the form of the imposition by the "upper strata" and the absorption by the "lower strata" of specific systems of theoretical views; and,

finally, the worldview aspect—the formation of a set of beliefs and convictions regarding the individual's place and role in the universal interconnectedness of historical objects and processes.

The affinity between symbol and dialogue lies primarily in their capacity to unite what appears to be fundamentally divided. In this sense, M.M. Bakhtin's assertion that "to be means to be in dialogue" is entirely apt. Understanding requires its actualisation within the space of culture. For the Christian interpretation—or rather, experience—of history, this meant, among other things: first, explaining the earthly world in connection with a world of an entirely different ontological order—the heavenly world; and second, constructing a picture of the world consistent with the spirit and letter of Holy Scripture. The solution was found precisely in the symbol as a method of explaining being through the union of two worlds, a means of connecting the phenomenon with that which it signifies but which remains elusive without this unity (*Makarov, 2009, p. 89*). The experience and understanding of history flow into the individual's value orientation—ultimately, into the existential experience of being, what M.M. Bakhtin termed the philosophy of the act.

Dialogue is intended to create, where there is no scientific-conceptual ("purposively rational") explanation of the world, an ordered yet all-encompassing system of social life in all its main regularities. Cultural memory in history serves as a bridge between abstraction and imagined representation—all the more so since even scientific abstraction necessarily involves the effect of imagination. Dialogue precisely "brings together" – without dissolving one into the other—different forms of cultural creativity and historical existence.

Within topological subjectivity—and it is precisely this we must speak of—operate realities that are incommensurable in classical reflection: if you will, everything begins to be exchanged for everything else, and the rhythm of equivalent exchange is disrupted. Thus, we may speak not only of the production of subjectivity as a describable process but also of an economy of subjectivity as a particular form of self-organisation and domestic arrangement of the self (*Gryakalov, 2010, pp. 220–221*). The hermeneutics of "historical factuality", therefore, in its present interpretation, must address the issue of identifying the subjects of history: "…the being into which we are thrown and to which we respond from within is characterised in historical terms." (*Vattimo, 2005, p. 120*) The problem of interpretation becomes especially acute in the context of the global and post-global world, where the informational and mass media effects on historical consciousness are particularly manifest.

The transmission of historicity is disrupted in the process of deforming the subject of social memory into the "mass man", to use the term of José Ortega y Gasset, whose psychology is based on a belief in the primordial nature of civilisation comparable to that of nature itself. This belief, as V.V. Balakhonsky and L.V. Balakhonskaya rightly point out, produces in the "mass man" a sense of complacency—a conviction that life ought to be easy, like a game, and free from consciously accepted social constraints. He is not prone to doubt, and he feels entitled to disregard others, to neglect historical memory, and to reject fundamental cultural values (*Balakhonskaya & Balakhonsky, 2012, p. 282*).

Discussion

The main scholarly problem outlined in the article lies in the need to conceptualise the social imaginary as a fundamental category within the epistemology of history—one capable of integrating processes of historical subjectivity, social memory, and the logical-procedural organisation of historical time. The focus is on the phenomenon of the imaginary as a symbolic field where fragmentary elements of historical reality are synthesised into coherent images of the past, present, and possible futures. This issue reflects a growing need to rethink traditional forms of historiography and to move beyond the classical rationalist model, which tends to reduce the historical subject and disregard the ontological value of memory.

Research into this topic faces several challenges. Firstly, there is no unified categorical framework into which the phenomenon of the imaginary can be incorporated within the context of historical knowledge: the boundaries between epistemological, ontological, and cultural-anthropological levels of analysis remain blurred. Secondly, social memory, as a multi-layered phenomenon, interacts not only with history but also with mentality, the collective unconscious, and archetypes, thereby necessitating an interdisciplinary approach and complicating the methodology of analysis. Finally, the virtualisation of historical consciousness—amplified by media environments and digital technologies—gives rise to new forms of historical identity that demand adequate tools for scholarly interpretation.

Several promising avenues for further research may be outlined.

The first involves the development of a theory of the symbolic imaginary within the epistemology of history, aimed at analysing the transboundary and metaphorical structures of historical thought.

The second concerns the study of the compensatory and integrative functions of social memory in the context of cultural fragmentation and post-historical sensitivity.

The third line of inquiry relates to the modelling of dialogical strategies in the epistemology of history, in which the subject and collective consciousness are viewed as active participants in meaning-making under conditions of interpretative plurality.

These directions not only open up new horizons for historiosophy but also contribute to the formation of a stable paradigm of meaning and value orientation for the individual in an era marked by a crisis of historical identity.

Conclusion

The formation of the "mass man" in contemporary society poses the threat of disrupting the transmission of historicity, undermining social continuity, and degrading the historical memory of society.

Thus, it is precisely the dialogue between values and discursive formations that renders the space of cultures internally correlated within the domain of memory. Accordingly, in the epistemology of history, an inner unity is constructed among various "discursive projects" (art, philosophy, religion, the political and economic organisation of society). Within this topological interaction, the internal dialogism of culture is revealed—in the transmission of historicity, the "discursive energy" of the epistemological unity of history comes into play.

Conflict of Interest

The author declares that there is no conflict of interest.

References:

Ankersmit, F. R. (1994). *History and Tropology: The Rise and Fall of Metaphor*. University of California Press.

Bakhtin, M. V. (2014). *Epistemology of Socio-Historical Knowledge (Models of History and Philosophical-Anthropological Representations)* [Dissertation on Doctor of Philosophical Sciences, Russian State Pedagogical University]. St. Peterburg. (In Russ.)

Balakhonskaya, L. V., & Balakhonsky, V. V. (2012). The Security of Society: Historical-Philosophical and Theoretical Aspects of Interpretation. *Bulletin of Saint Petersburg University of the Ministry of Internal Affairs of Russia: Scientific-Theoretical Journal*, *1*(53), 278–285. (In Russ.)

Castoriadis, C. (1987). *The Imaginary Institution of Society*. Cambridge, Massachusetts: MIT Press.

Domańska, E. (1998). *Encounters: Philosophy of History after Postmodernism*. Charlottesville: University Press of Virginia.

Gryakalov, A. A. (2010). Night in the Light of Day: On the Hermeneutics of Subjectivity. *Bulletin of Leningrad State University named after A.S. Pushkin. Philosophy*, *2*(4), 220–221. (In Russ.)

Gusev, S. S. (2003). *The Meaning of the Possible: Connotative Semantics*. St. Petersburg: Aleteya. (In Russ.)

Makarov, A. I. (2009). *The Phenomenon of Supra-Individual Memory: Image – Concept – Identity*. Volgograd. (In Russ.)

Mudragey, N. S. (1989). The Middle Ages and Scientific Thought. *Problems of Philosophy*, *12*, 86–89. (In Russ.)

Vattimo, G., & Rorty, R. (2005). The Age of Interpretation. In *The Future of Religion* (pp. 43-54). Columbia University Press.

Aidarov, Z. [a][5], *Usupova, C.* [b][6], *Satybaldieva, R.* [c][7], *Barynbaeva, A.* [d][8], *Kulzhanova, A.* [e][9]

BIOETHICS AS A RESPONSIBLE ATTITUDE TO THE TECHNICAL DEVELOPMENT OF MEDICINE [4]

Abstract: The rapid growth of technology in the natural sciences in the 21st century has brought to the forefront of humanity questions about the moral character of scientific achievements: in genetic modification of all living things, cloning, ethical issues of voluntary death, donation, environmental ethics, and so on. The study subject is aspects of responsible behavior in bioethics (moral and ethical standards) related to medical practices and environmental issues. The study object is bioethics, principles and their application in various spheres. The study aims to analyze foreign literature in the context of the problems of bioethics as a responsible attitude not only to medicine, but also to ecology, as a new standard for the development of moral and ethical standards appropriate to the time. The study used methods of content and comparative analysis of foreign publications in the background of bioethical issues. In the study, the authors considered many works, but mainly relied on the work of M.N. Dudin "Transgenic organisms (GMOs) in agriculture," which highlighted the problem of the need to develop scientific knowledge based on morality in solving many vital problems. The second paper that served as the primary source for the analysis was an article on the first authorized clinical trial of gene therapy in U.S. history, which was conducted on September 14, 1990 at the National Institutes of Health (NIH) under the direction of William Anderson. Main results of the study: Because of theoretical analysis of the works—GMO-plants can solve the problems of food security; gene therapy helps to successfully combat genetic diseases, but what will be the consequences of various types of interventions in nature, it is difficult to predict. The authors conclude that the introduction of a new bioethical paradigm is a matter of survival for all humankind. However, the practical application of bioethical norms is hampered by the fact that effective measures of responsibility and inevitable punishment for non-compliance with the principles of bioethics have not yet been developed.

Keywords: bioethics, responsibility, moral, ethical standards, technological progress, medicine, future of humanity.

Introduction

The modern development of medicine, namely its technological component, inevitably leads to the idea of a gap between the level of spiritual development and technology. Therefore, the issue of responsibility of scientists of different professions in the context of bioethics as a necessary standard of behavior in research and practice is relevant for all humanity. The solution of food security is the primary task of any state, but at what ecological cost it will be solved is a

[a] Ziiabidin Aidarov, Professor, Doctor of Medical Sciences, I.K. Akhunbaev Kyrgyz State Medical Academy. Bishkek, Kyrgyzstan. ORCID 0000-0003-2323-5702. E-mail: aydarov.kgma@gmail.com

[b] Cholpon Usupova, Doctor of Philosophical Sciences, Department Head, Department of Philosophy and Social Sciences, I.K. Akhunbaev Kyrgyz State Medical Academy. Bishkek, Kyrgyzstan. ORCID 0000-0001-7231-2642. E-mail: usupova.tcholpon@yandex.ru

[c] Rachat Satybaldieva, Senior Lecturer, Department of Philosophy and Social Sciences, I.K. Akhunbaev Kyrgyz State Medical Academy. Bishkek, Kyrgyzstan. ORCID 0000-0002-0429-3192. E-mail: satybaldieva.rakhat@mail.ru

[d] Ainura Barynbaeva, Researcher in Medicine, Kyrgyz State Medical College. Osh, Kyrgyzstan. ORCID 0000-0001-8062-7193. E-mail: abarynbaeva75@mail.ru

[e] Ainura Kulzhanova, Researcher in Medicine, Deputy Dean, Faculty of Postgraduate Medical Education, I.K. Akhunbaev Kyrgyz State Medical Academy. Bishkek, Kyrgyzstan. ORCID 0000-0002-1184-9371. E-mail: kuljanovaa@mail.ru

fundamental question for all nations. Modern civilization understands that ignoring environmental problems can lead to a catastrophic end for the humankind. It is bioethics—as an interdisciplinary field of knowledge located at the intersection of philosophy, law, medicine, sociology, political science, demography, cultural studies, and religious studies—that investigates the moral aspects of human attitudes to all phenomena that can solve the urgent problems of the 21st century. Bioethics includes a wide range of socio-economic, moral, ethical and legal issues, as universal values should not be considered separately from biological facts.

The study subject is aspects of responsible behavior in bioethics (moral and ethical standards) related to medical practices and environmental issues.

The study object is bioethics, principles and their application in various spheres.

The study aims to retrospectively analyze the works on the problems of GMO crops use in agriculture.

Based on the purpose, the following tasks were solved:

- consider the very first officially authorized developments on DNA correction;
- conduct a comparative analysis of articles on similar problems in the works of other authors;
- analyze the need for bioethics as a new standard for the development of moral and ethical norms appropriate to the times;
- raise questions of responsible behavior not only in medicine but also in ecology.

In this study, we considered many works, but mainly relied on the work of M.N. Dudin "Transgenic organisms (GMOs) in agriculture", which highlighted the problem of the need to develop scientific knowledge based on morality in solving many vital problems. The second paper that served as the primary source for the analysis was an article on the first authorized clinical trial of gene therapy in United States' history, which was conducted on September 14, 1990 at the National Institutes of Health (NIH) under the direction of William Anderson. At the present stage, there are many works devoted to the problem of ethical character in scientific research "Bioethics and Global Challenges, Documents and Reflections" (*Sayamov, 2020, p. 7*), Lenoir N. Respect for life and the right to life in the ethics of life (*Lenoir, 1998*), M.N. Dudin Transgenic organisms (GMOs) in agriculture: an objective necessity to ensure global food security or a way to increase the profits of the agro-industrial complex, many other literary sources consider the need to develop scientific knowledge based on morality, and the need to solve many vital problems with the help of the latest scientific achievements (*Dudin, 2020*). At the same time, the attention of the world community is paid to these issues at the highest level, an example is the international documents on these issues such as "Food|United Nations" (*Food, 2025*) and "Genetically modified Organisms (GMOs)" (*Genetically Modified Organisms…, 2009*). These documents say a lot about the positive aspects and the introduction of bioethical committees in the development of new technologies and scientific discoveries. However, questions of responsibility for possible harmful consequences of thoughtless and uncontrolled use of modern scientific discoveries currently remain open. One of the key problems is the problems of responsibility and the inevitability of punishment. «Bioethics is aimed at developing moral and ethical norms, requirements and principles, creating mechanisms to ensure the use of scientific and technological achievements for the benefit of man and nature." (*Sayamov, 2020,*

p. 7) Thus, Federico Mayor noted "the growing importance of bioethics for a person, where his dignity and equality are the basis of rights and duties in society." (*Sayamov, 2020, p. 8*) According to the ideas of tenerism, which echo all existing beliefs, a person is only a small fraction, a particle of everything that exists, and a careful attitude to the surrounding world and the preservation of inner spirituality, purity of thoughts is the most important imperative. This provision has materialized in many international treaties and concepts. Thus, Noel Lenoir, who headed the International Committee on Bioethics, believed that the "concept of bioethical protection should be applied to all forms of life" (*Lenoir, 1998*). In our opinion, this concept is more than relevant, although it is overdue, since experiments with GMO technologies have been introduced since the last century. The slogans under which GMO technologies were promoted were more than humanistic in order to feed all the suffering, but there were hungry people, and they remained, and environmental problems intensified.

Materials and Methods

The purpose is to analyze foreign literature in the context of the problems of bioethics as a responsible attitude not only to medicine, but also to ecology, as a new standard for the development of moral and ethical standards appropriate to the time. The objective is to reveal the problems of responsible attitudes in innovative achievements in the framework of environmental security. Design is "The Method of Qualitative Document Analysis". The novelty of the work lies in the fact that we have examined the composite subject of bioethics based on a combination of the idiographic method of cognition and the nomothetic method, with the former dominating. The nomothetic method is quantitative, while the idiographic is qualitative. Thus, using a combination of nomothetic and idiographic methods, we analyzed two works on the use of innovative technologies in the plant and human genome, one of which solves the global problem of hunger, but may be a source of congenital genetic diseases in humans. This combination of methods is an example of integration, a synergetic approach. The natural sciences, especially medicine, being a largely nomothetic science, reflect any private object as an expression of generic concepts to be replaced, while the idiographic sciences, to which bioethics belongs, view the object as a unique whole.

The combination of methods contributes to overcoming apparent technologism in bioethical communication. Using the idiographic-nomothetic method, it is possible to conduct sociological monitoring of the state of society, as well as to project social reality. The combination of both methods helps to eliminate conformism in bioethics, which, due to moral relativism and legal conflicts in different countries, adheres to a minimum level of morality. This fact demonstrates that it is not always possible to maintain a responsible attitude on the part of scientists, and under certain conditions bioethics cannot maintain generally accepted standards of moral norms. The limitation in the study is associated with the use of predominantly qualitative method, and to a lesser extent quantitative method. The subjective nature of the documents analyzed, the limited number of documents studied, which could affect the objectivity of the results.

Results

According to the latest edition of "The State of Food Security and Nutrition in the World 2020", in 2019, almost 690 million people worldwide were hungry—10 million more than in 2018, and almost 60 million more than five years ago. In addition, billions of people cannot afford healthy and nutritious foods due to their high cost and low availability. Asia has the largest number of hungry people, but in Africa their number is growing at the fastest pace (*Food, 2025*). Unfortunately, the most popular products of the poor—tomatoes, soybeans, corn, rice, potatoes—have undergone genetic processing. If there were no laws regarding the use of GMO products before, today in Europe, in Russia, these products are partially banned. For example, in Russia, crops of genetically modified wheat are in Stavropol, Altai and Kuban, so the population of these areas is exposed to certain risks. The euphoria from the effectiveness and phenomenal properties of genetically modified crops contributed to the fact that by the end of 2008 the area of GMO crops exceeded 114.2 million hectares. According to the most conservative estimates, these crops were grown by about 10 million farmers in 21 countries of the world (*Genetically Modified Organisms…, 2009*). In our opinion, a paradoxical situation has developed—countries with a high standard of living, first of all, were obliged to be on the alert because of the safety of public health. In our opinion, they (the richest countries) had to produce GMO crops, and the rest (poor) had to grow and consume, thereby putting themselves at risk, but we see from the figure (*Gene Therapy…, 2017*) that by 2019, agricultural land for GMOs amounted to 191.7 million hectares.

Since 2013, the absolute and relative growth has slowed down and amounted to 18 million hectares, or 23.9%, respectively, for the period 2013-2019 (at the beginning of the year) (*Figure 1*).

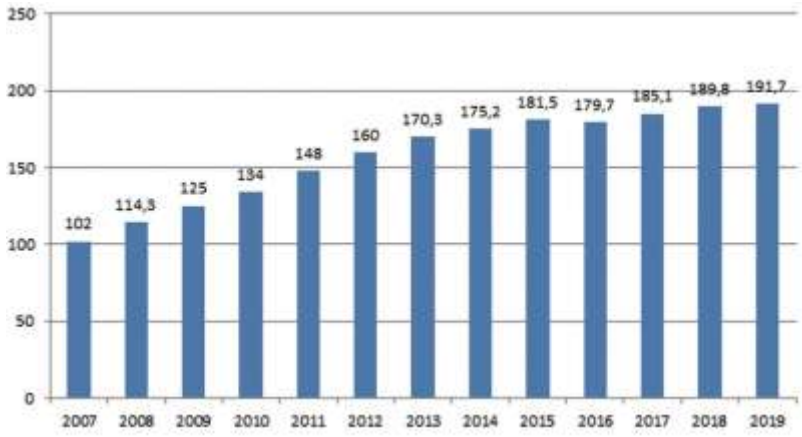

Figure 1. Areas under GMO products (*Dudin, 2020*)

Thus, although growth has slowed down, but has not decreased, acreage is still given over to GMO products. M.N. Dudin believes that the harm from products with GMOs is greatly exaggerated and in fact the widespread deterioration of health is nothing more than the result of pesticide treatment, as well as from harmful food additives. Positive aspects of GMO technologies M.N. Dudin argues, referring to the following: The economic benefits of using GMOs are multifaceted:

- increasing the efficiency of agricultural production;
- increasing crop yields;

- reducing crop diseases and losses from pests and adverse weather conditions;
- reducing pest control costs.

In particular, it is believed that all economic benefits, including resistance to drought and pests, higher yields and lower costs, lead to increased food security.

Ensuring food security—increasing the gross harvest of basic food crops, such as rice, corn, soybeans, directly increases the level of food security, especially in third world countries (*Dudin, 2020, p. 115*). Reducing the environmental threat: reducing the volume of pesticides by an average of 37% (*Klümper & Matin Qaim, 2014*). At the same time, M.N. Dudin points to the dubious advantage of reducing the number of harmful insects. However, in nature, in the absolute sense of the word, there are no harmful and useful insects. Pointing to the reduction of pollution of soil, rivers and reservoirs from the production of agricultural crops, as well as animals and fish, we must understand that with a reasonable and careful attitude to nature, negative consequences from agriculture and animal husbandry can be avoided. And regardless of how protected GMO technologies are, one thing is for sure: a person produces plants, animals and birds that will affect the ecosystem, since the delayed manifestation of unpredictable new properties of a transgenic organism is unknown and the danger of manifestation in several generations is probably inevitable, which may lead to the appearance of unplanned mutants that will be resistant to transgenic bacteria and other organisms. The microflora of a person consuming GMO products may be resistant to antibiotics. Scientists suggest that as a result of the use of marker genes, there is a threat that the genes of GMO products will pass into the human intestinal microflora. The created chimeras of plant origin do not give further harvest after a single use, as well as the offspring of birds and animals. Accordingly, the need to buy the source material every time puts everyone in a dependent position. Of course, supporters of genetically modified foods will certainly point out that, firstly, this is all assumed, and secondly, the process is not complete, but the scientific community, in my opinion, should be very careful when interfering with the genome of living beings. The generation of the 20th century watched with amazement how technological advances in the field of natural sciences gave rise to phenomena from science fiction films. And, perhaps, they live in captivity of stereotypes, however, according to the ancient proverb, what you eat is what you eat, so, in the end, eating GMO foods, we ourselves to some extent become chimeras, and as a natural result, new congenital genetic diseases can arise, the genesis of which will be genetically modified products. Progress does not stand still, so the ongoing work on changing the genome of plants and animals later began to be performed in humans, first not publicly, and then at the official level. An example and a successful result of this is the fight against genetic diseases. It is believed that one of the first authorized in American history was a clinical study in gene therapy, which took place on September 14, 1990 at the National Institutes of Health under the leadership of William Anderson. Four-year-old Ashanti Desilva was being treated for a severe genetic defect of complex combined immunodeficiency associated with a deficiency of the enzyme ADA. In the blood taken from the patient, the defective gene was replaced by a functional variant. This led to a partial restoration of the Ashanti immune system. This temporarily stimulated the production of the missing enzyme, but did not lead to the formation of new cells with a functional gene. Ashanti continued to receive corrected T-cell injections every two months and could lead a normal life (*Bulletin of Roszdravnadzor, 2011*). This success inspired and gave hope to

many people for healing from genetic diseases. In modern medicine, the definition of gene therapy is accepted as a method of treating (correcting) diseases (hereditary, multifactorial, acquired (infectious), oncological) by introducing foreign (missing) genetic information (genes) into the tissues or cells of the patient to change gene defects or give cells new functions (*FGBNTSSMP…, 2024*). Initially, gene therapy was considered as a means of treating hereditary diseases at the genetic level, i.e., correction of the genome at the level of the DNA molecule. However, at present, the use of gene therapy has significantly expanded and includes not only methods of correcting hereditary pathologies and acquired diseases, but also the treatment of viral infections at the genetic level by introducing full-fledged functionally active (therapeutic) genes or DNA sequences regulating gene activity into cells (*FGBNTSSMP…, 2024*). In fact, in the future, many medicines, like a magic wand, will heal suffering. However, human intervention in nature is not always predictable, and many years of clinical research are required for their safe use. The big question is what kind of supervisory authorities should be in order to effectively influence the scientific community, as well as the people who finance these projects. Since genetic technologies promise huge dividends and temptations, such as world fame, a lot of money. There are always a lot of scammers around this, who repeatedly and radiantly describe the possibilities of genetic engineering to the entire world community. In this regard, a group of scientists J.P. Evans, E.M. Meslin, T.M. Marto, T. Caulfield from the USA, Great Britain and Canada in their recent article in the journal Science drew readers' attention to the inflating "genetic bubble"—people's hopes that the achievements of genetic medicine will be realized in the near future and will find their practical application are not sufficiently substantiated yet. The authors of the article urge not to succumb to "genetic euphoria" (*Evans et al., 2011*). Perhaps one of the most advanced control systems today is the System of Authorization of Gene Therapy procedures in the United States, since it is multi-step, and each protocol for a future procedure must be approved first by the Biosafety Committee, and then by an Advisory Committee at the National Institutes of Health. It is further reviewed by the National Food and Drug Safety Service. After the appropriate approval, the protocol is published in the journal "Human Gene Therapy," and each protocol is approximately 30–40, up to 50 pages of the smallest font, where all the details, all the safety issues are reflected (*The First Gene Therapy…, 2021*). To date, the FDA has not issued a single permit for the widespread clinical use of gene therapy drugs (*Bulletin of Roszdravnadzor, 2011*). At the same time, the US National Institutes of Health officially published data on almost two thousand clinical trials using gene therapy drugs at the first to third phase level (*The International Council…, 2021*). The development of gene therapy in the United States, as well as in Japan and Australia, is an example of how regulation occurs through dynamic guidelines and rules, according to which protocols are drawn up and certain manipulations are allowed. The European Medicines Agency (EMEA) is actively working in this area. This medicines quality control body has published a number of guidelines and recommendations concerning gene therapy drugs, of which the Guidelines for Preclinical Research, Guidelines for Clinical Monitoring, and yet to be approved Guidelines on the Quality, Preclinical and Clinical Aspects of Medical Devices containing Genetically Modified Cells should be noted. In some European countries, such as Austria, Sweden, Norway and France, existing laws on genetic engineering have been supplemented with sections on gene therapy. A special group on gene therapy is very actively involved in the work of the International

Conference on the Harmonization of Drug Requirements (ICH) (*Global Ethics Observatory, 2024*). Many international organizations, realizing the need for control, are working to create effective measures. For example: UNESCO has engaged in the development of human genetics and bioethics at the global level. An important achievement in this work was the adoption in October 2005 of the Universal Declaration on Bioethics and Human Rights (*Dommel & Alexander, 1997*). Along with them, such normative documents as the Helsinki Declaration of the World Medical Association "Ethical Principles of Medical Research with Human Participation" (1964, the 2000 edition is applied) are used for international legal regulation in the field of bioethics (*Dommel & Alexander, 1997*), The Council of Europe Convention on Human Rights and Biomedicine (1997) and its Additional Protocols concerning the prohibition of human cloning, transplantation, and biomedical research (*United Nations Declaration…, 2005*). Thus, the entire progressive community understands that these organizations are trying to streamline and introduce technological progress in a civilized way. However, life on planet Earth does not fit into the established framework. Despite the specifics of medical knowledge and the content of the educational process, the formation of a responsible and bioethically developed personality of a medical specialist is formal. The doctor's consciousness is closest to philosophical thinking, since the object of research is life and death as such. In the history of philosophical thought, it is quite difficult to find a thinker who would bypass the problem of life and death. Plato's famous statement that philosophy is nothing but preparation for death and the ability to die, which was subsequently repeatedly reproduced in various versions and words by other sages and philosophers (*Plato, 1990, p. 70*). Existentialism has become one of the most popular trends in modern realities, since life and death are one of the main categories, the salt of the uniqueness of human existence. The most prominent representative of existentialism, M. Heidegger, considering the problem of the meaning of being, took its finiteness as one of the main defining characteristics of human existence and deduced another, no less important category, characteristic of being, namely time. Largely because of the finiteness of human existence, only for man, as M. Heidegger argued, it is "open" in the sense that only he has an understanding of being (*Heidegger, 2006*). According to many existentialists, the specificity of human existence largely determines his freedom, which, however, cannot be separated from his responsibility. Freedom and responsibility are one of the central categories of another outstanding representative of existentialism, J.-P. Sartre, who, like his like-minded people, recognized exclusively individual responsibility, which, moreover, meant, in fact, the responsibility of a person, an individual before his beliefs (*Sartre, 2002, p. 20*). However, in the modern era, when humanistic ethics is undergoing revision, revision and a new one is being intensively formed, in particular, environmental ethics, there is a need and necessity for a new interpretation of humanism, considering rapid changes both in human existence and in man himself and his psychology. Modern achievements and achievements in biomedical practice and technologies, as P.V. Tishchenko emphasizes, radically transform traditional ideas about the limits of human existence, about existential principles of personality, about moral and immoral, about freedom and responsibility, about justice, etc. (*Yudin & Tishchenko, 1998*). The content of the category of responsibility is quite rich and ambiguous. In recent decades, attempts have been made to interpret responsibility in the plane of the so-called activity-oriented, meaningful, communication-sociological, philosophical-sociological approaches. From the point of view of

the activity approach, responsibility is interpreted as an individual's awareness of his personal duty to society as a whole, a certain circle of people, as well as his duties, the meaning and consequences of his actions, the need to be responsible for them, for his behavior, as the ability to admit his guilt. In the "Modern Explanatory Dictionary of the Russian language," edited by S.Y. Kuznetsov, responsibility is defined as "the need to give an account of their actions, deeds, etc.; the obligation to be responsible for their possible consequences; the seriousness, importance of something" (*Kuznetsov, 2008*). "The modern philosophy of responsibility recognizes the human person in its true meaning, appeals to the spiritual understanding of the essence of man, while demanding from the state to ensure the sustainable development of a just society." (*Osipov, 2014*) "It is worth noting that the development of a sense of the responsibility of the individual towards the state and of the state towards the individual is of no small importance in bioethics. However, the state is made up of human beings, so initially it is necessary to achieve a full understanding of the responsibility of the individual, first and foremost, to himself or herself. Scientific and technological progress is not only a source of civilizational advantage, but it often threatens human existence." (*Seidalieva & Barynbaeva, 2017*) Bioethics, therefore, is one of the phenomena of social consciousness that will change the thinking of all mankind in the future.

Discussion

The study aims to analyze the problem of bioethics as a responsible attitude not only in medicine, but also in ecology, as a new standard for the development of moral and ethical norms in science. Currently, the use of gene therapy has become ubiquitous and it is not only the correction of hereditary pathologies, but also the creation of new technologies for the introduction of full-fledged functionally active genes with specific tasks. Existing organizations providing control over the introduction of innovative technologies in medicine in the USA, Canada, Australia and Europe seem to guarantee compliance with bioethical norms. However, from time to time, news of the use of genetic engineering without adherence to bioethics standards breaks through, confirming the need for strict control over new technologies. In the global world, there are still varying understandings and perceptions of bioethics in different cultures. There is an ongoing discussion in the global community about the need to create international standards and norms to regulate new technologies to accommodate cultural differences and ethical norms ("Regulating Emerging Technologies: A Global Perspective", "The Role of Ethics in Technology Regulation"). In the United States and European countries, genetic testing has become widespread and this poses a threat to the possibility of data leakage. India and China are investing heavily in biotechnology and genetic research. In China, genome-editing technologies (CRISPR-Cas9) are actively used to treat genetic diseases and improve crops. According to the laws of dialectics, any phenomenon has positive and negative sides, so in the 21st century we should consider all possible consequences of these technologies. Limitations of the study are related to the subjectivity of the analysis and the insufficient number of documents reviewed. The implications of the study emphasize the need to develop and implement new moral and ethical standards, based on new international legal instruments.

Conclusion

We investigated the problems of responsible attitude to innovative achievements in the framework of environmental security. Based on theoretical analysis of articles of various nature: on GMO-technologies in agricultural production can indeed solve the problems of food security of all mankind, genotherapy in practice has shown its success in the fight against hereditary diseases. However, human intervention in nature is not always predictable, and their safe use requires years of clinical trials. The big question is what oversight bodies should exist to effectively influence the scientific community, as well as the people who fund these projects. After all, gene technology promises dividends: money and world fame. Thus, we believe that: a philosophical understanding and interpretation of the concept of bioethics as a social and professional responsibility is impossible without an understanding of the need for moral and ethical standards in matters of scientific and professional activity. In this connection, we suggest that bioethics be taught from an early age as eco-bioethics, and that it be presented at universities as global and social bioethics. Because the organization and forms of teaching bioethics are inadequate to the demands of our time and hinder the formation of bioethical ideas, attitudes, abilities, knowledge and skills in students. In the future, we will continue research in this area to develop the categorical and conceptual apparatus of bioethics.

Acknowledgments

The authors express their special gratitude for the critical remarks, as well as for the help in promoting the article for publication to Doctor of Philosophy, Professor M.V. Bakhtin, Doctor of Economics Alexander Buychik, Doctor of Philosophy, Professor E.K. Sharipova.

Conflict of Interest

The authors declare that there is no conflict of interest.

References:

Bulletin of Roszdravnadzor, No. 4 (2011). (In Russ.). https://fgu.ru/journal/#page-journal-archive

Dommel, F. W., & Alexander, D. (1997). The Convention on Human Rights and Biomedicine of the Council of Europe. *Kennedy Institute of Ethics Journal*, *7*(3), 259–276. https://doi.org/10.1353/ken.1997.0023

Dudin, M. N. (2020). Transgenic Organisms (GMOs) in Agriculture: An Objective Necessity to Ensure Global Food Security or a Way to Increase the Profits of TNC Agro-Industrial Complex. *Food Policy and Security*, *7*(2), 107–119. (In Russ.)

Evans, J. P., Meslin, E. M., Marteau, T. M., & Caulfield, T. (2011). Deflating the Genomic Bubble. *Science*, *331*(6019), 861–862. https://doi.org/10.1126/science.1198039

FGBNTSSMP of the Ministry of Health. State and Prospects for the Development of Gene Therapy in Russia. (2024, December 10). *BioInformatix*. http://bioinformatix.ru

Food. (2025, January 11). *United Nations*. https://www.un.org/en/global-issues/food

Gene Therapy for "Children in a Bubble". (2017, October 25). *Analytical portal Polit.Ru.* (In Russ.). https://www.polit.ru>article>2017/10/25>ps_adascid

Genetically Modified Organisms (GMOs). (2009, November 05). RIA Novosti. (In Russ.). https://ria.ru

Global Ethics Observatory. (2024, December 16). *UNESCO*. http://www.unesco.org/shs/ethics/geobs

Heidegger, M. (2006). Essays on Philosophy. About the Event. *Issues of Philosophy*, *11*, 164–166. https://doi.org/10.1111/j.1475-5661.2012.00550.x

Klümper, W., & Matin Qaim, M. (2014). Meta-Analysis of the Impacts of Genetically Modified Crops. *PLoS ONE*, *9*(11), e111629. https://doi.org/10.1371/journal.pone.0111629

Kuznetsov, S. A. (Ed.). (2008). *Modern Explanatory Dictionary of the Russian Language*. St. Petersburg, Moscow: Norint, RIPOL Classic. (In Russ.)

Lenoir, N. (1998). Respect de la vie et droit du vivant. In *The ethics of life (L'éthique du vivant)* (pp. 175–211). Paris: UNESCO. (In Fra.)

Osipov, I. D. (2014). The Paradigm of Responsibility in European Philosophy. *Bulletin of the St. Petersburg State University*, *17*(2), 52–63. (In Russ.)

Plato. (1990). *Apology of Socrates. Plato Works: In 4 volumes* (Vol. 1). Moscow. (In Russ.)

Sartre, J.-P. (2002). *Diaries of a Strange War. September, 1939 – March, 1940*. Moscow: Publishing House "Vladimir Dal".

Sayamov, Y. N. (2020). *Bioethics and Global Challenges. Documents and reflections*. Moscow: Veche.

Seidalieva, M. K., & Barynbaeva, A. A. (2017). Topical Issues of Bioethics. *International Academy Journal*, *6*(15), 85–87.

The Convention on Human Rights and Biomedicine of the Council of Europe. (2021). *PubMed*. https://pubmed.ncbi.nlm.gov/11660358

The First Gene Therapy. Life Sciences Foundation. (2021). *U.S. Food and Drug Administration*. http://www.fda.gov/BiologicsBloodVaccines/CellularGeneTherapyProducts/default.htm

The International Council for Harmonisation. (2021). *The International Council for Harmonisation*. http://www.ich.org/cache/compo/276-254-1.html

United Nations Declaration on Human Cloning. General Assembly Resolution 59/280 of 8 March 2005. (2005). *United Nations*. https://press.un.org/en/2005/ga10333.doc.htm

Yudin, B. L., & Tishchenko, P. D. (Ed.). (1998). *Introduction to Bioethics*. Moscow: Progress-Tradition. (In Russ.)

Dashuai, C. [a][10], *Usupova, C.* [b][6], *Abdyldaev, M.* [c][11], *Satybaldieva, R.* [d][12]

PROBLEMS OF CULTIVATING IDEOLOGICAL SECURITY IN THE EDUCATIONAL ENVIRONMENT [5]

Abstract: In the 21st century the forgotten word combination ideological security has received a new impetus, it turned out that by creating, through modern technologies, a certain information field it is possible to perform any political decisions and change the mental attitude of the population. Accordingly, the issues of this nature have become particularly relevant in the national states. The security of the state is largely related to the creation of national ideology, which is formed in the minds of young people. The study aims to explore effective methods and approaches to creating ideological security in educational institutions, objectives, teach critical and logical thinking techniques, as well as understand what an ideologically safe environment means. The main objective of the study is to study effective approaches in teaching ideological security in educational institutions. Methodological approaches and methods are the poly-subject approach provided a deep understanding of the student as a multifaceted personality, which is most fully manifested in communication with others. The authors used thematic triangulation of data, followed by comparative analysis, as well as methods of descriptive statistics. A participatory approach to teaching ideological security to youth audiences was utilized. Surveys, questionnaires, interviews were used as research tools that helped to create a verifiable picture. In the results authors present created teacher-student parity increase the chances of creating a safe space, interactive discourse method reduces susceptibility to ideological extremism. In conclusion, this paper makes a practical contribution to the understanding of ideological security in the classroom by proposing a transformational paradigm of social consciousness within secondary and higher education.

Keywords: ideology; students; ideological security; critical thinking; open dialog; education.

Introduction

For more than half a century of human history, educational institutions have been centers of intellectual discourse, contributing to the maturation of young minds. Students, especially in the last decade, are at the epicenter of information innovations and are exposed to all sorts of influences. The dynamism and turbulence of the modern world create pressing problems characterized by the alternativeness and almost lightning-fast dissemination of information, which is first and foremost aimed at a youth audience susceptible to various ideological manipulations and extremism. Therefore, critical, logical, dialectical thinking and ideological stability of students are necessary competences of the 21st century, which are ontologically demanded by sovereign countries. Since it is these skills that contribute to the understanding of the essence and existence of modern independent state existence. Thus, the relevance of

[a] Chen Dashuai, Doctoral Student of the Department of Philosophy, Theory and History of Culture, Kyrgyz National University. Bishkek, Kyrgyz Republic. ORCID 0009-0005-3977-4446. E-mail: 469718738@qq.com

[b] Cholpon Usupova, Doctor of Philosophical Sciences, Department Head, Department of Philosophy and Social Sciences, I.K. Akhunbaev Kyrgyz State Medical Academy. Bishkek, Kyrgyzstan. ORCID 0000-0001-7231-2642. E-mail: usupova.tcholpon@yandex.ru

[c] Marat Abdyldaev, Researcher, National Institute for Strategic Initiatives, Kyrgyz National University. Bishkek, Kyrgyz Republic. E-mail: 3martab.abd@mail.ru

[d] Rakhat Satybaldieva, Senior Lecturer, Department of Philosophy and Social Sciences, I.K. Akhunbaev Kyrgyz State Medical Academy, Bishkek, Kyrgyz Republic. ORCID 0000-0002-0429-3192. E-mail: satybaldieva.rakhat@mail.ru

studying the problem of creating an ideologically safe environment that promotes state independence is of paramount importance.

The study aims to explore effective methods and approaches to creating ideological security in educational institutions, objectives, teach critical and logical thinking techniques, as well as understand what an ideologically safe environment means.

Despite recognizing the importance of teaching ideological security, the empirical approaches of application in secondary and higher education are not equally developed and relevant in application in different countries. Existing works on this problem, recognize the need to develop critical thinking, media literacy, and cultivate ideological resilience in college and university students. However, the ability to think critically and competently evaluate any materials at the present stage is not sufficiently developed not only among students, but also among highly educated people (political elite) (*Leaning, 2019*). We should note a large number of works in the People's Republic of China devoted to the problems of ideological education.

Systematic developments in this area in the Kyrgyz Republic remain rare, unfortunately, there are no comprehensive scientific studies of effective strategies and implementation mechanisms for organizing ideological security. However, President S. Zhaparov is seriously concerned about the problems of ideological security in the state, as evidenced by publications on this topic. Thus, this study is aimed at solving an important task – to create ideological security in the educational environment, by forming certain attitudes in the minds of students, increasing anti-manipulative resistance, the ability to critical thinking and the practice of "open dialog" (*Inquiry…, 2022*). Considering these aspects, we aim to deepen our understanding of ideological education role in formatting students' skills to recognize falsified data, comprehend different viewpoints and understand the need to create an ideologically safe environment.

Materials

A thorough review of the existing literature revealed a growing number of studies in Russia and China, as well as the emergence of interest in this problem in Kyrgyzstan, devoted to teaching students of educational institutions ideological security. These studies emphasize the key role of higher education in shaping ideological attitudes in students and developing their ability to think critically. We should note the overlapping interest in media education or media literacy often considered in foreign universities with the problem of creating an ideologically safe environment in educational institutions of the European Union, Canada, America, South Korea, and Japan throughout the 20th and 21st century. There is a separate history of considering the issues of ideological education in North Korea (*Demick, 2013*; *Zakharova, 2022*; *Zhebin, 2020*; *Khamutaeva, 2016*) and in Islamic states. Publications on the problem of interest to us in full are difficult to access, but even according to the available literature we note dogmatized ideologization starting from preschool institutions. In the 20th century in Japan, South Korea, many researchers noted the rise of national consciousness at all stages of the educational process, introduced into consciousness image-symbolic concepts: homeland, nation, people, fate. It is worth noting that this policy mobilized the population for selfless work for the benefit of the state. Japan and South Korea have achieved significant economic success, where a special role was played by the rise of national consciousness, in addition to other important aspects (*Yagnakova & Vasilieva, 2016*; *Bogatyrev, 2023*). In the 21st century, there has been a significant

decrease in the level of education ideologization in Japan and South Korea. In the U.S., discussions about ideologically safe environment in education are mainly in the context of "tolerance for different viewpoints and the ability to hear opponents, and the key question is whether it is the right decision to allow into the walls of educational institutions speakers who can mislead and direct students to the dangerous path of red thoughts." (*Boch, 2022*) We believe that this tactic is important for fostering polemic skills, critical thinking, and in some ways feelings of patriotism, but to a greater extent, it has the character of adherence to some political views. In an array of published studies, the work of M. Smith and P. Walsh (*2023*) directly addressed the issues of ideological security and the need to educate students in the context of patriotism. We observe a global trend. All publications emphasize the issues of credibility of information influencing the consciousness of young people. In the 21st century, specially created digital simulacra, are able to model any information space and program entire generations at will. Therefore, a special place is occupied by developing critical thinking in the era of "post-truth" (*Mejia et al., 2018*). The problem of critical thinking as a resource for objective reflection has been studied in many universities around the world (*Bellaera et al., 2021*; *Lu & Wang, 2021*; *Frykholm, 2021*; *Evendi et al., 2022*; *Toropova, 2023*; *Solodikhina & Solodikhina, 2019*; *Pavlovskij & Pavlovskaya, 2024*; *Dienichieva et al., 2021*; *Hsu, 2021*). Meanwhile, the issues of patriotism education through the formation of citizenship have been touched upon in rare works; interest was aroused by the publication where the civic position was considered from the angle of "transforming action of agency" (*Pevnaya et al., 2024*). In the EU, national patriotism issues are relegated to the level of attractiveness of living in the context of comfort without emphasizing love for the homeland, mostly as consumer ideology development.

Analysis of publications in the post-Soviet space shows that in the "perestroika years" many union states abandoned the educational role in universities, focusing on the provision of educational services. However, this trend has changed and issues of ideological security in the educational environment are slowly being raised, particularly in Russia and Kyrgyzstan. For example, research was conducted on the phenomena of postmodernist ideology of education in the late 20th and 21st centuries (the priority of individualism, egocentrism). Based on the conclusions, the authors revealed the need for a value-oriented approach in the educational process in universities, the need to educate moral qualities in students (*Sakharchuk et al., 2023*; *Voytyuk, 2019*; *Agutin, 2023*; *Bobkov, 2023*; *Lomakina, 2023*; *Lykov, 2020*). In the post-Soviet space, the only state that has not interrupted the work on creating an ideologically safe environment is Belarus (*Sakharchuk et al., 2023*). There are many works devoted to the issues affecting the phenomenon of ideological security in the context of hybrid information wars (*Kefeli & Komleva, 2019*), as well as works devoted to analyzing the state of universities (through the eyes of students of different periods) (*Rusina, 2019*). Youth as a focus group was also considered by other authors, who noted the importance of its role in creating a dialogue that promotes cooperation as one of the civilizational mechanisms for creating a safe environment (*Brusilovsky, et al., 2017*). Higher education institutions become a fertile ground for assessing the effectiveness of ideological security training in countering any kind of manipulation, developing constructive dialog and preventing extremism. The works of foreign authors analyze quantitative studies that illustrate the transformational potential of education in ideological security. It is noted that "empirical analysis emphasizes ideological security education role in

building resilience to extremist ideological manipulation, offering insights into effective pedagogical approaches." (*Sarah, 2017*) As suggested by C. M. Greene and G. Murphy (*2021*), interactive simulations and role-plays facilitate the exploration of ideological conflicts and possible ways to resolve them. Structured conversations emphasizing active listening and divergent thinking offer a framework for respectful interaction with different viewpoints (*Bataeva, 2019*). A study conducted at Hanan University confirmed the view that almost all Chinese educational institutions consider understanding their history, are willing to consciously defend national sovereignty, and demonstrate greater tolerance and empathy. This is how ideological security in China is taught, which plays a significant role in fostering responsible citizenship in students. With the skills to respectfully debate and consider different viewpoints, students can make positive contributions to society and solve complex social problems (*Jiang et al., 2018*). Through in-depth interviews with students, these studies emphasize the role of teachers in forming an environment conducive to open dialogue and critical reflection. In the works of foreign authors, it was revealed that modern media technologies purposefully affect emotional points, leading to cognitive dissonance, irrational thinking, and not accepting the "voice of reason" (critical thinking) (*Higgins, 2016*). An interesting aspect of ensuring information-psychological security in educational institutions has been brought to the general review by Russian researchers (*Kuznetsova & Lugovskoy, 2023*). We should note that the issues of ideological security are historically most developed in China, as evidenced by the works of Feng Gang, Shi Hongyue devoted to moral values, which are directly associated with a stable traditional way of life, implying a safe space. The problems of ideological and political education of Chinese college students occupy a special place (*Shen, 2020*). In the Republic of China, given the ongoing changes in the global world, the influence of the teacher on the moral formation of the student is analyzed in a new way. The main message on introducing ideological security is observed from the first person of China Xi Jinping (*2020*). There is a tendency of increasing interest in educating the younger generation, in the aspect of developing critical thinking around the world. New pedagogical approaches affecting the safety of educational space are actively implemented in the EU countries, as well as in South Korea, starting from school education, such as phenomenon-oriented learning, transversal competencies, project-based learning, integrated learning and inquiry-based learning (*Dolgaya, 2019*). One of the vanguards of pedagogical innovation is schools in Finland, where the principle of prioritizing a holistic approach to problems, combined with digital technologies (*Symeonidis & Schwarz, 2016*). Digitalization plays a great role in creating various training programs for developing critical thinking. However, the dominance of information technology can have various negative effects: a decrease in mental abilities, dependence on gadgets, a decrease in interests concerning issues of a wider range, such as the sovereignty of the state, the dominance of virtual reality, but let us not deny the positive aspects (communication without regard to geographical boundaries, access to various types of information, the possibility of online certification, etc.) (*Korovnikova, 2021*).

Thus, having considered the trends in education in the United States and the European Union in educational institutions, we came to the conclusion that in recent decades the ideological vector has changed significantly from national interests to transnational interests (environmental movement, dominance of liberalism, etc.), which is significantly different from Russia, China, as well as Kyrgyzstan, which are on the way to create their national ideology.

Addressing critical thinking in pedagogical strategies in different countries plays an important role in creating a safe space. All skills capable of forming different viewpoints and developing in students the ability to thoughtfully, tolerantly understand ideological complexities are especially relevant in the period of Third World War's threat. Therefore, due to the turbulence of the surrounding world, there are relevant topics for further study, as the emerging trend of a multipolar world, which requires a new reading of ideological security, especially in educational institutions. Therefore, the systematic integration of ideological security education and the development of comprehensive pedagogical models remain in demand.

Methodology, Materials, and Methods

This study utilized a diverse set of research methods and tools to comprehensively examine the impact of ideological security education among college students including:

(1) case study methodology;
(2) survey and questionnaire methodology;
(3) comparative analysis method;
(4) interview method;
(5) triangulation of the obtained data.

The first stage of our study was conducted on the basis of Hanan Pedagogical University (China) from February 20 to May 25, 2023, the second stage was conducted on the basis of J. Balasagyn Kyrgyz National University (Kyrgyzstan). In this article we analyze the study conducted in the People's Republic of China. Using the method of cohort analysis (students as a cohort), we identified changes in attitudes toward ideological education before and after classes, debates, and round tables between students and teachers in the aspect of critical thinking development. In the first stage, 50 1st and 2nd year students and 4 educators of Hanan University of Education participated in the study. Before conducting the study, the trainees were informed about the purpose and objectives of the research work. A case study methodology was used to gain insight into the implementation and experiences of teaching ideological security in real university settings. A representative institution was selected to study different teaching strategies and their outcomes. Key variables include course content, the role of instructors, and student perceptions of the learning environment. In-depth interviews conducted by instructors with students, as well as analysis of documents containing course materials, provided a multifaceted view of aspects of ideological security education. In this study, qualitative and quantitative data were collected through surveys and questionnaires, and interviewing. The instruments developed measure variables such as students' attitudes toward ideological education to create a safe environment, susceptibility to manipulation, and self-assessment of critical thinking abilities. This approach allows for a comprehensive examination of factors influencing students' engagement in ideological security, we developed a semi-structured interview protocol to explore and students' perceptions of the pedagogical effectiveness of encountered problems and desired outcomes of ideological security education. Through this qualitative method, variables such as the role of the instructor, the impact on developing critical thinking, and encouraging open dialog are explored. A comparative analysis was conducted to identify differences and commonalities in implementing and outcoming ideological security education across institutions. The approach triangulated data from literature reviews, case studies, surveys,

and interviews to gain a deeper understanding of differences in teaching strategies, student experiences, and learning outcomes. Quantitative data from the surveys were analyzed using descriptive statistical techniques. Qualitative data from interviews and document analysis were thematically analyzed to identify recurring patterns, emerging themes, and insightful narratives. Combining the quantitative and qualitative data facilitated a comprehensive interpretation of the findings to provide a holistic view of impacting ideological security education on university students. The variables measured were:

- Attitudes towards ideological security education;
- Perceived vulnerability to ideological manipulation;
- Critical thinking skills for self-assessment;
- Faculty role in promotion;
- Faculty role in promoting ideological security education;
- Student involvement in exploring different perspectives;
- Effectiveness of instructional strategies.

Comparative analysis matrices and descriptive and thematic data analysis techniques were used in analyzing the documents.

In the conducted study, the criteria for the effectiveness of the conducted experiment were before and after statistics, level of self-efficacy, COR- all students declared as participants reached the end of the study.

Results

To get a complete picture of the sample of the ongoing study in Chinese and Kyrgyz higher education institutions, we decided to study the demographic profile of the participants. In this article, we review the first phase of the study, which involved 50 Chinese undergraduate students. Demographic data on the distribution of participants by age, gender, social status, and nationality. In this study, the sample consisted of 50 people willing to participate in the experiment, these were the students who took social and humanities disciplines and 4 teachers who teach these disciplines. The number of students was justified by the fact that to conduct in-depth interviewing and other works for the teachers involved in this stage of the study was a rather labor-intensive process.

Table 1. Demographics of the participants

Statistics (n=50)	Frequency	Percentage
Возраст		
18-20 лет	15	30%
21-23 лет	22	44%
24 лет и выше	13	26%
Male gender	24	48%
Female gender	26	52%
Education	Part-time higher education	100%
Nationality	Chinese people	100%
Marital status	Single	100%
Scope of activity	Student	100%

As the results of the study show, the number of students aged 21–23 years old is 44%, which is much higher than in other age categories, and women are the majority among them—52%, marital status is 100% single, and the represented nationality is Chinese.

While conducting the work on how the process of teaching ideological security affects the ability to engage in open dialog and discuss different viewpoints, participants were asked to evaluate their experiences before and after attending the relevant courses. The changes in students' attitudes toward dialoguing with people who hold opposing views and are insecure show that attending classes, emphasizing critical thinking, lead to developing logical and reflective thinking skills. In the course of the experiment, we recorded the change in the attitude of students to the issues of participation in the discussion of opposing viewpoints. The results showed that after attending the courses there was a significant shift, participants noted an increased willingness to engage in constructive dialog, which indicates the positive impact of ideological security training.

In developing critical thinking skills, participants were presented with scenarios requiring critical analysis of information sources. Table 2 presents the distribution of answers about the effectiveness of ideological security training in developing critical thinking skills. The distribution of responses about the effectiveness of ideological security education in developing critical thinking skills shows that the number of agreements reaches 49% before the training and increases to 90% after.

Table 2. Opinions on the development of critical thinking skills

Education in the development of critical thinking skills			P-value
Answer options	Before the training	After the training	(t-test)
Agreed	49%	90%	0,001
Difficult to answer	29%	8%	0,007
Disagree.	22%	2%	0,002

Thus, the data showed a significant increase in the number of participants who agreed or strongly agreed that ideological security education promotes critical thinking skills we believe that the study data is statistically significant differences before and after training P (t-test) – 0.001.

Table 3. Evaluating the effectiveness of different training methods

Methods of teaching	Effectively	Neutral	Ineffectively
Discussion	85%	10%	5%
Research work (examples)	85%	13%	2%
Interactive seminars	90%	8%	2%

Table 3 shows the participants' evaluations of the effectiveness of different teaching methods. According to the parameters of teaching methods' effectiveness, it would seem that discussion and case studies are equally effective, but discussion in the percentage of ineffectiveness reaches 5%, we associate that with case studies (examples) during practical work reaches 2%. Thus, the use of the activity approach is more effective. Interactive seminars were

found to be very effective (90%) in developing ideological security. The results of this study emphasize the significance of ideological security education in shaping students' perceptions, attitudes and skills. Positive effects on developing critical thinking, open dialog, resistance to manipulation, and interaction with different viewpoints were identified. In addition, the comparative analysis of teaching methods provided valuable insights into effective pedagogical approaches. They illustrate the positive impact on developing critical thinking, the introduction of open dialog leading to increased resistance to manipulation and engagement with different viewpoints The findings contribute to a broader discussion on ideological security education and provide practical recommendations for teachers, educational institutions and policy makers.

The findings indicate the critical role of ideological security education in shaping the perceptions, attitudes and skills of university students. The identified positive findings from the study provide valuable insights into the potential benefits of integrating such instruction into secondary and tertiary curricula. An important implication of this work is to understand the constructive impact of ideological security education on developing critical thinking skills in university students. The findings suggest that exposure to different perspectives and discussions stimulate learners to challenge assumptions, critically analyze information, and evaluate the validity of different viewpoints. This underscores the importance of incorporating different disciplines into the ideological security curriculum, developing intellectual curiosity and the ability of students to engage in competent analytical discourse. By creating a safe space to discuss different viewpoints, students learn effective communication skills, actively practice attentive listening, and engage in constructive discussions. This emphasizes the potential of introducing facilitated discussion and dialogue. Another notable result has been an increase in students' resistance to manipulation. Teaching ideological security equips students with tools to recognize and counter manipulative strategies, misinformation, and propaganda. This result emphasizes the importance of including the competencies of "media literacy" in the curriculum (*Rochford, 2003*) and critical evaluation of information to enable students to make informed decisions and navigate the increasingly confusing media landscape. The results suggest a positive relationship between fostering ideological security and exposure to diverse viewpoints. Exposing students to a wide range of ideologies, allows them to engage in meaningful dialogues and make sense of different cultural, social, and political contexts. Thus, the findings emphasize the need for interdisciplinary courses that promote cross-cultural understanding and foster a sense of global citizenship, as well as support the sovereignty of nation-states. The comparative analysis of pedagogical approaches in this study provides valuable insights into effective methods for teaching ideological security. The identification of successful strategies such as interactive discourse, case studies, and collaborative projects provide practical guidance for educators seeking to develop effective and engaging curricula. Thus, a combination of interactive and participatory methods can optimize the outcomes of ideological security education initiatives.

Discussion

Integrating an ideological security program into the educational process enables students to navigate political intricacies, critically evaluate information, engage in informed discourse, and contribute positively to their communities, strengthening citizenship and patriotism. The findings highlight the potential of ideological security education to shape students' attitudes,

skills, and behaviors in response to contemporary challenges. Similar studies have shown similar results, e.g., at Bridgewater University, a teacher at the University of Bridgewater, realizing that ideological bias could hinder productive dialogue, introduced ideological security into the course. Students in the "Global Perspectives on Socio-Political Issues Course", participated in structured debates on controversial issues, which showed an increased level of awareness. Throughout the semester, students participated in debates where they had to argue a viewpoint contrary to their beliefs. Conducted seminars at Hanan University revealed that combining reflective exercises and critical analysis of media sources not only honed students' ability to identify manipulative narratives, but also cultivated an understanding of other groups' motives. Jennifer Lee noted a similar result "the integration of targeted ideological safety activities allowed students to effectively engage with diverse perspectives" in her work (*Lee, 2016*). A significant place in teaching an ideologically safe environment is given to understanding the role of media tools, therefore, in the PRC in the government's policy implementation a special role is given to information technology. Unfortunately, we must say that there is often misleading and sometimes intentionally distorted information that substitutes for true facts, so it is so necessary to develop information education.

The trend of introducing media literacy into the educational process, in the context of which critical thinking skills are developed, began in European countries, then in Canada and America in the 1920s–1940s and since then there have been several periods of promotion of these courses. For example, in response to the proliferation of misinformation on the Internet, an elective course on Digital Citizenship and Media Literacy was offered at All City College. Professor Martinez has developed assignments that allow students to critically evaluate the credibility of digital sources of information, recognize bias, and identify echo chambers. In the 21st century, the globalization of the Internet has made these courses especially relevant. Manipulation in the information sphere, where digital holograms create a parallel reality inevitably generates the need to counteract mental barriers. The joint projects conducted were devoted to fact-checking and validation of information, which allowed students to acquire the necessary skills to navigate the complex information landscape and make informed decisions.

In this study, the authors did not touch upon the problem of inclusiveness, but we plan to consider the problem of tolerance education as another factor in creating a safe environment at the second stage (in Kyrgyzstan). A good example can be the education of inclusiveness through intercultural dialog conducted at Harmony University course "Intercultural Communication", which promotes intercultural education as another factor in creating a safe environment (*Brown, 2019*), promoting intercultural understanding through ideologically safe teaching. In fostering ideological safety, our study utilized interactive workshops and intercultural dialogues to facilitate the exploration of cultural perspectives and biases. Which helped to increase self-awareness, develop empathy. Therefore, the authors believe that creating an atmosphere of mutual respect and understanding through ideological security education also contributes to a more inclusive and harmonious student community. The problem of extremism very often arises in foreign universities, so measures to counter the emergence of extremist narratives are particularly relevant. Thus, Horizon University actively counteracts the rise of extremist ideologies on campus by organizing seminars led by ideological security experts (ISE). These workshops provide students with historical context, analytical tools, and counter-stories to

recognize and counter extremist ideologies. By equipping students with the knowledge and skills to deconstruct manipulative narratives, the university empowers them to resist ideological exploitation, contributing to a safer and more sustainable campus environment. In the West, there are entire fields of study that work in the context of building critical and logical thinking, such as the Leadership and Ethics course at Pioneer College under the direction of Professor Carter that integrates ideological security education. Students analyze the ethical implications of different ideological views through case studies and debates. By dealing with complex ethical dilemmas arising from conflicting ideologies, students refine their ethical reasoning skills and develop the ability to lead with integrity in a world rich in ideological diversity. Each of the examples presented here highlights the transformative potential of ideological security education, reinforcing the importance of its integration into diverse academic environments. By successfully adopting the experiences of foreign counterparts in China and equipping students with the necessary skills to navigate ideological complexities, critically evaluate information, engage in informed discourse, and make positive contributions to society, ideological security education is becoming a critical tool for students' holistic development.

Limitations of the Study. Although this study was able to draw insightful conclusions, some limitations are worth recognizing. The relatively modest sample size of 50 participants may limit the generalizability of the findings. In addition, the reliance on self-reported data may introduce bias in participants' responses. The study examined mainly short-term effects, and long-term effects require further investigation.

Directions for Future Research. To address these shortcomings and expand the knowledge base, we plan to examine the long-term effects of ideological security training on college students in the future. Longitudinal studies tracking participants over time could provide insight into sustained effects on critical thinking, open dialog, and engagement with diverse perspectives. Additionally, involving more diverse and representative samples would allow for a more nuanced analysis of the impact of ideological security training on different demographic groups.

Conclusion

Given the historical context, empirical evidence and contemporary imperatives, the importance of ideological security education is undeniable. Conducted a comprehensive study of students' ideological security, empirical examples have demonstrated the role in the development of the ability to distinguish, analyze different viewpoints. The empirical rationale presented emphasizes the urgent need to organically integrate ideological security training into higher education. By developing critical thinking, supporting open discourse, building resilience to manipulation, and engaging with diverse viewpoints, ideological security education provides students with the necessary tools to address the complex challenges of the modern era. Through meticulous research and careful analysis, the potential effectiveness of ideological security education and its profound impact on students' disposition, immunity to manipulation, ability to think critically, and receptivity to dialog are revealed. This paper can serve as a compass to guide educators, educational institutions, and policy makers in thinking about the best approaches to navigating the maze of ideological diversity. It is a beacon pointing the way to educational methods that are not only effective but also transformative, beckoning to enlightenment, empowerment and harmony in the educational environment.

Acknowledgments

The authors would like to thank Nurjamal Tashmatovna Karasheva, candidate of pedagogical sciences, for help in statistical calculations, Natalia Padalkina, editorial director of the Medical Journal of the Kyrgyz State Medical Academy, and all anonymous reviewers.

Conflict of Interest

The authors declare that there is no conflict of interest.

References:

Agutin, A. V. (2023). Spiritual bonds of national education and liberal ideology: dialectic of spiritual and moral (concrete) and immoral (abstract). *Journal of Applied Research*, *1*, 167–171. (In Russ.). https://doi.org/10.47576/2712-7516_2023_1_167

Averkov, A. N. (2022). State ideology and basis for designing educational work in educational institutions. *Bulletin of Polessky State University. Series in Social Sciences and Humanities*, *2*, 58–64. https://cyberleninka.ru/article/n/state-ideology-and-basis-for-designing-educational-work-in-educational-institutions

Bataeva, E. V. (2019). Cognitive and metacognitive skills of students in the context of SMART-education. *The Education and Science Journal*, *21*(4), 36–59. (In Russ.). https://doi.org/10.17853/1994-5639-2019-4-36-59

Bellaera, L., Weinstein-Jones, J., Llie, S., & Baker, S. T. (2021). Critical thinking in practice: the priorities and practices of instructors teaching in higher education. *Thinking Skills and Creativity*, *41*(4), 100856. https://doi.org/10.1016/j.tsc.2021.100856

Bobkov, A. I. (2023). Education without ideology, or the end of the idea of the university. *Juridical Science and Practice. Bulletin of the Nizhny Novgorod Academy of the Russian Ministry of Internal Affairs*, *1*(61), 178–181. (In Russ.)

Bogatyrev, V. V. (2023). Ideology of education – the basis of state security. *Legal Support of National Security. Thirty Years of Legislation on the Security of the Russian Federation: Materials of the All-Russian Scientific and Practical Conference RANEPA*, 51–55. Moscow: Prospect. (In Russ.)

Boch, A. (2022). The Limits of Tolerance: Extreme Speakers on Campus. *Social Problems*, *69*(1), 143–163. https://doi.org/10.1093/socpro/spaa019

Brown, M. (2019). Promoting open dialogue: The role of ideological security education. *Teaching and Learning in Higher Education*, 1, 67–82.

Brusilovsky, D. A., Angel, O. V., & Meshcheriakova, Y. V. (2017). Youth cooperation as one of the mechanisms of dialogue of civilizations (methodological aspects). *Innovative practice in the Eurasian Economic Union: power, business, science. Collection of Materials of the International Scientific-Practical Conference: In 2 Parts*, *1*, 202–209. Arkhangelsk: PEI of HE 'Institute of Management'. (In Russ.)

Demick, B. (2013). *Ordinary lives in North Korea.* Moscow: Alpina. (In Russ.)

Dienichieva, O. I., Komogorova, M., Lukianchuk, S., Teletska, L. I., & Yankovska, I. M. (2021). From Reflection to Self-Assessment: Methods of Developing Critical Thinking in Students. *International Journal of Education and Information Technologies*, *15*, 227–236. https://doi.org/10.46300/9109.2021.15.2

Dolgaya, O. I. (2019). World tendencies in general education: new ideology of education and change of psychological and pedagogical approaches to teaching. *Pedagogical Journal of Bashkortostan*, *6*(85), 32–39. (In Russ.)

Evendi, E., Al Kusaeri, A. K., & Pardi, M. H. H., et al. (2022). Assessing students' critical thinking skills viewed from cognitive style: Study on implementation of problem-based e-learning model in mathematics courses. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(7), em2129. https://doi.org/10.29333/ejmste/12161

Frykholm, J. (2021). Critical thinking and the humanities: a case study of conceptualizations and teaching practices at the section for cinema studies at Stockholm University. *Arts and Humanities in Higher Education*, *20*(3), 253-273. https://doi.org/10.1177/1474022220948798

Greene, C. M., & Murphy, G. (2021). Quantifying the effects of fake news on behavior: Evidence from a study of COVID-19 misinformation. *Journal of Experimental Psychology: Applied*, *27*(4), 773–784. https://doi.org/10.1037/xap0000371

Higgins, K. (2016). Post-truth: a guide for the perplexed. *Nature*, *540*(7631), 9. https://doi.org/10.1038/540009a

Hsu, Y-C. (2021). Action research in critical thinking concept designed curriculum based on collaborative learning for engineering ethics course. *Sustainability*, *13*(5), 2621. https://doi.org/10.3390/su13052621

Inquiry into national security risks affecting the Australian higher education and research sector. (2022). Parliament of the Commonwealth of Australia. Canberra. https://www.aph.gov.au/Parliamentary_Business/Committees/Joint/Intelligence_and_Security/NationalSecurityRisks/Report

Jiang, Y., Zhang, J., & Xin, T. (2018). Toward education quality improvement in China: A brief overview of the national assessment of education quality. *Journal of Educational and Behavioral Statistics*, *44*(6), 733–751. https://doi.org/10.3102/1076998618809677

Kefeli, I. F., & Komleva, N. A. (2019). On the role of information and ideological security the counter-strategy hybrid war in Eurasia. *EURASIAN INTEGRATION: Economics, Law, Politics*, *1*, 54–60. (In Russ.)

Khamutaeva, C. V. (2016). Conservatism as a political philosophy in South and North Korea. *Bulletin of Buryat State University. Philosophy*, *6*, 120–127. (In Russ.) https://doi.org/10.18101/1994-0866-2016-6-120-127

Kuznetsova, N. V., & Lugovskoy, A. V. (2023). The development of critical thinking for information and psychological security assurance among university students. *The World of Science, Culture and Education*, *1*(98), 22–25. (In Russ.). https://doi.org/10.24412/1991-5497-2023-198-22-25

Leaning, M. (2019). An Approach to Digital Literacy through the Integration of Media and Information Literacy. *Media and Communication*, *7*(2), 4−13. https://doi.org/10.17645/mac.v7i2.1931

Lee, J. (2016). Strategies for enhancing ideological resilience in college. *Journal of Higher Education Research*, *2*, 201–218.

Lomakina, I. S. (2023). Influence of neoliberal ideology on the change of value orientations in the education system. *Features of Socio-Economic Development of the Region: Legal, Managerial and Socio-Humanitarian Aspects*, 435–441. Cheboksary: Chuvash State Pedagogical University named after I.Y. Yakovlev. (In Russ.)

Lu, G., & Wang, J. (2021). Relationships between teacher autonomy, collaboration, and critical thinking focused instruction: a cross-national study. *International Journal of Educational Research*, *106*, 101730. https://doi.org/10.1016/j.ijer.2020.101730

Lykov, A. V. (2020). Ideology and education. *University Complex As a Regional Centre of Education, Science And Culture. Proceedings of the All-Russian Scientific And Methodological Conference (with International Participation)*, 1320–1328. Orenburg: Orenburg State University. (In Russ.)

Korovnikova, N. A. (2021). Artificial intelligence in the modern educational space: problems and prospects. *Social Novelties and Social Sciences*, *2*(4), 98–113. (In Russ.). https://doi.org/10.31249/snsn/2021.02.07

Mejia, R., Beckermann, K., & Sullivan, C. (2018). White lies: a racial history of the (post)truth. *Communication and Critical/Cultural Studies*, *15*(2), 109–126. https://doi.org/10.1080/14791420.2018.1456668

Pavlovskij, A. I., & Pavlovskaya, O. V. (2024). Assessment of students' critical thinking maturity in the process of teaching philosophy. *The Education and science journal*, *26*(5), 40–66. (In Russ.). https://doi.org/10.17853/1994-5639-2024-5-40-66

Pevnaya, M. V., Tarasova, A. N., Telepaeva, D. F., & Protasov, D. S. (2024). Transformative agency of students as a resource to form civic consciousness in education system. *The Education and Science Journal*, *26*(4), 169–200. (In Russ.). https://doi.org/10.17853/1994-5639-2024-4-169-200

Rochford, F. (2003). Academic freedom as insubordination: the legalisation of the academy. *Education and the Law*, *15*(4), 249–262. https://www.nwpolytech.ca/files/forms _documents/AcademicFreedom_INsubordination.pdf

Rusina, Y. A. (2019). The Everyday Life of a Ural Higher Educational Institution in the Epoch of Changes (Second Half of the 1980s–1990s): Oral History View. *Izvestia. UrFU. Series 2. Humanities and Arts*, *21*(1), 283–296. (In Russ.) http://elar.urfu.ru/handle/10995/69948

Sakharchuk, E. S., Kiseleva, I. A., Baghramyan, E. R., & Sakharchuk, A. L. (2023). Axiology of education: Ideals and unifying values in social education of modern student youth. *The Education and Science Journal*, *25*(3), 67–96. (In Russ.). https://doi.org/10.17853/1994-5639-2023-3-67-96

Sarah, W. (2017). Building resilience to ideological manipulation: An empirical analysis. *Higher Education Research*, *28*(4), 456–472.

Shen, J. (2020). *Report on the development of ideological and political education of Chinese college students 2018–2019*. Beijing: Beijing Normal University Publishing House. (In Chi.)

Smith, M., & Walsh, P. (2023). Security sensitive research: balancing research integrity, academic freedom and national interest. *Journal of Higher Education Policy and Management*, *45*(5), 495–510. https://doi.org/10.1080/1360080X.2023.2202328

Solodikhina, M. V., & Solodikhina, A. A. (2019). Development of critical thinking of master's degree students using STEM cases. *The Education and science journal*, 21(3), 125–153. (In Russ.). https://doi.org/10.17853/1994-5639-2019-3-125-153

Symeonidis, V., & Schwarz, J. F. (2016). Phenomenon-based teaching and learning through the pedagogical lenses of phenomenology: The recent curriculum reform in Finland. *Forum Oświatowe*, *28*(2), 31–47. https://www.researchgate.net/publication/313696751

Toropova, S. I. (2023). Development of critical thinking of students – future biotechnologists in the process of teaching mathematics. *The Education and Science Journal*, *25*(5), 49–76. (In Russ.). https://doi.org/10.17853/1994-5639-2023-5-49-76

Voytyuk, V. P. (2019). The role of ideology in the formation of the first state formations. In: A. G. Erzaulova (Ed.), *Myth. Culture. Ethnos: Collection of scientific articles on the materials of the All-Russian scientific conference 'April Yalta: Myth and Culture of Tavrida'* (pp. 50–53). Simferopol: ARIAL. (In Russ.)

Xi Jinping. (2020). *The governance of China* (vol. 3). Beijing: Foreign Language Publishers.

Yagnakova, E. Z., & Vasilieva, S. A. (2016). Ideologization of education in the modern world. *Eurasian Journal of Region and Political Research*, *1*(16), 72–85. (In Russ.)

Zakharova, L. (2022). A bumpy road to bright goals: North Korea's approach to implementing the 2030 agenda and prospects for international cooperation. *International Organisations Research Journal*, *17*(3), 175–193. https://doi.org/10.17323/1996-7845-2022-03-07

Zhebin, A. Z. (Ed.). (2020). *The Korean Peninsula: History and present times*. Moscow: RAS IFES Press. (In Russ.)

Solakov, R. [a][13]

GENERAL CHARACTERISTICS OF PROPERTY PROTECTION [6]

Abstract: The right to property is one of the fundamental subjective rights in modern legal systems, playing a key role in ensuring economic stability and social order. In the context of dynamic social, economic, and technological changes, increasing questions are being raised regarding the law and the protection of this right, the answers to which require careful analysis and adaptation of existing legal mechanisms. This article examines the protection of the right to property as a fundamental principle of the rule of law. It explores the general characteristics and diverse mechanisms for safeguarding property rights, including civil, administrative, and criminal legal protections. The study aims to identify and classify the primary methods of protection, analysing the normative framework, judicial practice, and legal scholarship, with particular emphasis on the jurisprudence of the Constitutional Court of the Republic of Bulgaria. The study demonstrates that property protection constitutes a dynamic legal domain, continuously adapting to socio-economic transformations that inherently impact the substantive right to ownership. In the contemporary context, the need for further legislative measures and refinement of protective mechanisms remains critically relevant. The author concludes that property protection is a dynamic legal figure whose effectiveness depends on the ability of the legislator and law enforcement bodies to integrate traditional principles into new realities, ensuring both the stability of legal relationships and compliance with international human rights standards.

Keywords: property, property law, protection of property, petitory claims.

Abbreviations:

ALO&UA is Agricultural Land Ownership and Use Act,
APC is Administrative Procedure Code,
C&PRA is Cadastre and Property Register Act,
CC is Criminal Code,
CCt is Constitutional Court,
CiPC is Civil Procedure Code,
CRB is Constitution of the Republic of Bulgaria,
CrPC is Criminal Procedure Code,
EU is European Union,
HR is Human Rights,
MPA is Municipal Property Act,
OU of ALA is Ownership and Use of Agricultural Land Act,
PA is Property Act,
PC is Penal Code,
SDA is Spatial Development Act,
SPA is State Property Act.

Introduction

[a] Rosen Solakov, Ph.D. Student, Department of Civil Law Sciences, Faculty of Law, Plovdiv University "Paisii Hilendarski". Plovdiv, Bulgaria. E-mail: rosen.solakov@uni-plovdiv.bg

The right to property is one of the fundamental subjective rights in modern legal systems, playing a key role in ensuring economic stability and social order. In the context of dynamic social, economic, and technological changes, increasing questions are being raised regarding the law and the protection of this right, the answers to which require careful analysis and adaptation of existing legal mechanisms.

This study focuses on the general characteristics of property protection, analysing the various legal instruments and mechanisms that guarantee the effective safeguarding of this right.

The study aims to identify and classify the main methods of property protection, as well as to analyse the contemporary challenges faced by this legal institution.

The study also examines the international legal aspects of protection.

The methodological approach includes a comparative analysis of legislation, case law, and legal doctrine, with particular attention to the practice of the Constitutional Court of the Republic of Bulgaria.

Concept

The right to ownership occupies a central place within the system of property rights and is a key element of the legal order in modern societies.

Art. 17, para. 3 of the CRB stipulates that private property is inviolable. It is the duty of the state to guarantee and protect the right of ownership and to ensure the inviolability of private property, which obliges the legislature to refrain from adopting legal measures that contradict the constitutional requirement for the protection of the inviolability of private property (*Decision, 2021*).

Art. 2, para. 2 of the PA establishes the principle that all forms of property enjoy equal opportunities for development and protection. According to Art. 86 PA, property that is publicly owned by the state or municipality cannot be acquired through prescription.

Bulgarian legislation does not contain a legal definition of the right of ownership. According to the classical Roman law definition, the right of ownership consists of three components (powers): ius utendi (use), ius fruendi (enjoyment/fruition), and ius abutendi (disposal) (*Andreev, 1993, p. 237*).

Other definitions also exist, deriving from Bulgarian legal scholarship. The right of ownership is defined as the right by which a person may require all others to refrain from any actions regarding a particular object (*Venedikov, 1991, p. 86*); as a legally recognised possibility for a person to exercise direct power over a specific object to satisfy their interests and to demand that all other persons refrain from interfering with it, to the extent permitted by law or the rights of third parties (*Tadjer, 1975, p. 35*); as an absolute subjective right, characterised by complete factual and legal authority over an object, enforceable against all other legal subjects, and including the powers of disposal, possession, and use, insofar as these powers are not limited by the legal order (*Dzherov, 2010, p. 85*); as a legally recognised and guaranteed opportunity for a person to possess, use, and dispose of a specific object and to require all others to refrain from interfering with it (*Boyanov, 2014, p. 107*); and as a subjective right that allows its holder to possess, use, and dispose of a specific object within the boundaries of the law, and to require all other subjects to refrain from interfering with that object (*Stoyanov, 2024, p. 73*).

In all the definitions mentioned, it stands out that, in addition to the owner's powers of possession, use, and disposal, the right of ownership is an absolute subjective real right. Corresponding to this right are the legal obligations of all other subjects not to violate it. For this reason, these rights can be asserted against all other persons. These legal obligations entail refraining from interfering with the holder's exercise of their subjective right. In this sense, infringements of the real right of ownership may be committed by any subject who, in any way, challenges, denies, or breaches the right of ownership, or otherwise obstructs the exercise of any of the powers of the titleholder. Since any subject may interfere with its exercise, the absolute nature of the right of ownership makes it vulnerable. Therefore, effective legislative mechanisms must exist to protect it against any encroachment.

Although the right of ownership is absolute, it is not unlimited and may be restricted either voluntarily by the will of its holder or compulsorily, when such limitation is provided for by law. The CRB and the legislation allow such restrictions, balancing the rights of the owner with higher legal values or public needs. These interventions, whether voluntary or compulsory, affect the substance of the right but do not provide grounds for protection when performed in accordance with procedures laid down by law. With regard to compulsory restrictions, such as the expropriation of property under Art. 17(5) of the CRB and further developed in the Expropriation of PA and the MPA, it should be emphasised that such encroachment on ownership hinges on a key balance between individual rights and the public interest, which is precisely why it is regulated at the constitutional level.

The right of ownership is the most fundamental and comprehensive of all subjective real rights. In the context of dynamic social, economic, and technological changes, it faces numerous contemporary challenges. From the regulation of urbanised territories to the management of virtual assets, its content and applicability are evolving and require adaptation to respond to new realities. The legal system follows the development of the world around us and seeks to regulate it. Inevitably, changes in social relations lead to changes in property law. The ways in which ownership is protected are also subject to change. At a more abstract level, the core of the classical doctrine of ownership retains its essence, yet the changes in our surrounding world generate developments in certain aspects of material property law. In view of this, changes in the legal framework and methods of protection are inevitable. The needs related to the existence and exercise of the subjective right of ownership cannot evolve without triggering changes in the mechanisms for its protection. These very changes introduce new, or pose challenges to, classical protective mechanisms. The resilience and adaptability of the so-called classical means of ownership protection are considerable, but insufficient. It is therefore inevitable that new mechanisms be introduced—specific means for the protection of property. In this way, the emergence, existence, and exercise of the subjective right of ownership remain guaranteed by the legal order for its holder in the event of potential disputes or violations by other subjects.

The genesis in the field of protecting the right to property stems from the fundamental postulate set forth in the CRB, namely that the legal system guarantees the protection of all subjective rights. The right to protection is constitutionally enshrined in Art. 56 of the CRB. It serves as a means to safeguard other violated or threatened rights or legitimate interests (Decision of the Constitutional Court No. 3 on Case No. 1/1994). The constitutional right to protection is an autonomous, fundamental, personal, universal, and complex right of citizens.

On the other hand, the right to protection is directly linked to every other right or legitimate interest. It gives rise to obligations for the state.

First and foremost, the state is obliged to ensure the individual exercise of the right to protection, and it must not hinder its realisation—this highlights its absolute nature. Secondly, the state has the duty to provide legal guarantees and various forms of safeguarding the fundamental rights established in the CRB at all levels of state authority. Thirdly, there is the obligation to ensure the state's protective function, which should reinforce institutions as democratic, public, and fair (*Cherneva et al., 2023, pp. 52–53*).

The right to property is fundamental to the existence and development of any legal system, yet it is simultaneously vulnerable to a range of factors that may threaten it. The voluntary fulfilment of legal obligations by all other parties in the legal relationship with the property owner is a legislative priority and aligns with the interests of the right holder, as well as with public interests more broadly. Voluntary fulfilment represents the most desirable development of the legal relationship. If the exercise of subjective rights were left solely to the goodwill of obligated parties, the very notion of legal order would become meaningless, as the defining characteristic of a legal system is that it contains mechanisms of coercion when voluntary compliance is absent. Coercive enforcement is a substitute for missing voluntary fulfilment (*Stalev et al., 2020, p. 897*). One of the essential attributes of law—coercion—means that it guarantees the subjective right to property (as well as other rights), and, when necessary, the holder may use the lawful means available to seek protection.

Property is not only a personal value but also an economic foundation. Without its legal protection, investments, transactions, or economic activity in general would be insecure. Historically, property has often been subject to unlawful expropriation or excessive state interference, which necessitates clearly regulated mechanisms for protection and for limiting such practices. The need to protect property arises from its role in guaranteeing individual freedom, economic stability, and public order. Violations of property rights may include disputes, theft, fraud, or other unauthorised actions of any kind, all of which require effective legal protection.

In this sense, the protection of the right to property is of essential importance both for the individual and for society. The free exercise of this right is in line with the principle of the rule of law—in both its formal and substantive sense. A classical component of the rule of law in the formal sense is the principle of legality, which serves to prevent arbitrariness. In the substantive sense, the rule of law is a state of justice, which, through principles such as the separation of powers, the inalienability of fundamental rights, and others, guarantees the free exercise of fundamental rights—among which the right to property undoubtedly belongs—and, consequently, their protection as well (*Drumeva, 2018, pp. 132–133*).

The protection of the right to property is of a complex nature. It is performed, on the one hand, through substantive legal norms that regulate the legal consequences which acts of law enforcement bodies have on the material civil legal relationship, and on the other hand, through procedural legal norms that regulate the procedural means and order for the realisation of such protection, as well as the procedural legal consequences of the acts of the bodies through which protection of the right to property is effected (*Pavlova, 2002, p. 215*).

The legal regulation of property protection is not systematised in a single legislative act. Substantive provisions can be found in numerous laws—not only in civil law, but also in administrative and criminal law—more specifically, in the CC and the CrPC. A comprehensive enumeration would be difficult, but rules for the protection of property in one form or another can be found in the PA, the SPA, the MPA, the SDA, the C&PRA, the restitution laws, among others.

The principal means of protection are legal claims—more specifically, proprietary claims. The classical claims for the protection of property are regulated in the PA. These include the reivindicatory claim under Art. 108 PA and the negatory claim under Art. 109 PA. Additionally, Art. 109a of the PA regulates the claim for determination of property boundaries. Other petitory claims can be found in special laws such as the C&PRA and the OU of ALA. The role of administrative protection of property is also increasing. There are numerous administrative legal means for the protection of property. These are often also regulated by civil laws—e.g., Art. 52 of the PA, Art. 80 of the SPA, and Art. 65(1) of the MPA. The CC also provides for offences against property, regulated in a separate Chapter V of the CC. Procedural laws determine the procedures by which protection is exercised. The primary one is the CiPC, though in many cases the APC applies. Proceedings in cases of offences against property are performed under the CrPC. In addition, international legal mechanisms, such as the protection guaranteed by the HR European Convention and the case-law of the HR European Court, further reinforce property as a fundamental right of every individual (*Panayotova-Chalukova, 2019, p. 163*).

It is worth noting that the means for the protection of property are applied as a general rule also to limited real rights, unless otherwise provided by law or if the nature of the remedy renders it inapplicable to limited real rights. This is particularly true for petitory claims, which is why they are considered a generic category of claims (*Stoinov, 2021, p. 103*).

Despite possible limitations, property protection is of a universal nature, as it is applied in all cases—whether in relation to private or public, movable or immovable property. Although there are differences depending on the criteria for protection, the law provides mechanisms to prevent and sanction unlawful infringements.

For property protection to be exercised, three general prerequisites must be in place. First, the claimant must be the owner or holder of a limited real right. In certain cases, where the public interest is affected, state intervention through its bodies is also possible, such as in the case of an offence against property within the meaning of the CC. Second, there must be a violation or infringement of the right, manifested in its contestation, denial, or direct breach. Third, the legal ground for protection must be provided by law, ensuring legal legitimacy and the possibility of protection through an established procedure.

The regulated means of protection contribute to the prevention of conflicts and self-redress, as the legal system guarantees the peaceful and just resolution of disputes. However, it is also necessary to adapt legal protection to the conditions of dynamic social, economic, and technological changes. New challenges require the improvement of existing mechanisms and the introduction of innovations for the effective protection of owners' rights.

In conclusion, the protection of property (and of limited real rights) represents a system of legal norms and principles by virtue of which the owner (or holder of a limited real right) may,

according to an established procedure, protect their right against denial, contestation, or direct violation of any of its powers.

Results

The right of ownership is protected through various means. The methods for protecting ownership are classified according to different criteria. These distinctions have significant practical importance, as noted in the preceding lines, since the right of ownership (as well as limited real rights) is fundamental to any modern legal system, and its protection must be comprehensive and complete to guarantee it in its entirety.

In a Broad and Narrow Sense

Given that there are various means of protection, it is necessary to distinguish the usage of the phrase "protection of property", as it is often used synonymously with petitory claims. Although these are among the fundamental and specialised legal remedies for the protection of property rights, they represent only one category of such means. This is because they constitute the proprietary aspect of protection, but do not exhaust the possibilities for safeguarding subjective property rights. Depending on numerous factors, different branches of law provide different mechanisms. Therefore, for a comprehensive interpretation of the term, one may conclude that a distinction must be made between protection of property in a broad sense and protection of property in a narrow sense.

In the narrow sense, protection of property encompasses all petitory claims. These claims also serve to protect limited real rights. They are considered the principal legal remedies, as they involve claims aimed at defending ownership and other property rights. Petitory claims are the typical legal instruments for the protection of property rights. This category includes classical remedies such as the rei vindicatio and the negatory action, but also more modern and specific claims, such as claims for the rectification of errors and omissions in the cadastral map under the CPRA, among others.

In the broad sense, protection of property includes all legal remedies provided by domestic and international law, as well as by EU law. This category naturally includes protection in the narrow sense but extends beyond it. Broadly speaking, it also encompasses all administrative and criminal law remedies, and all sources outside the domestic legislation of the Republic of Bulgaria—essentially, all mechanisms designed to safeguard property. These can be found, for example, in the CC under the chapter on protection of property, in the SPA and the MPA as examples of administrative protection, in the European Convention on Human Rights as a key source of international legal provisions, and others.

Classical and Specific

Legal remedies for the protection of property can also be divided into classical and specific. The distinguishing criterion between these two categories lies in the nature and legal characteristics of the protective mechanisms provided by law.

Classical remedies are characterised by general, abstract protection of the right of ownership. Most of them originate from earlier periods, dating back to Ancient Rome. Their abstract nature renders them enduring over time and adaptable through the ages. These

remedies are based on the absolute nature of property rights. The main classical remedies include:

- the rei vindicatio, used by a non-possessory owner to claim an item from a non-owning possessor;
- the negatory action, brought by the owner against interferences that do not involve deprivation of possession but affect their right and hinder its exercise;
- the action for declaration of ownership, used when the owner seeks to establish their right against a third party.

Specific remedies, on the other hand, involve more concrete, specialised mechanisms applicable to particular situations. They introduce diversity in the methods of protection, since infringements may vary depending on several factors—the nature of the violation, the object of protection, the type of ownership, etc. Specific remedies also diversify the way protection is implemented. There is a notable increase in the use of administrative mechanisms for protection.

Civil, Criminal, and Administrative Protection

The protection of property rights is divided into civil, criminal, and administrative protection.

Civil protection consists of civil claims established by the legislator, which are granted to the holder of a property right to defend it against unlawful interference. Civil protection should not be equated solely with petitory claims. It includes proprietary claims but is not limited to them. Therefore, civil protection may be classified into petitory claims and other civil-law methods of protection.

The category of petitory claims includes all proprietary claims—vindicatory (Art. 108 of the PA), negatory (Art. 109 of the PA, declaratory actions for determining boundaries (Art. 109a of the PA), claims concerning omissions or errors in the cadastral plan (Art. 54, para. 2 of the C&PRA), and others.

Petitory claims must be distinguished from possessory claims, also referred to as possessory remedies. Possessory protection comprises legal means for remedying disturbed possession (*Tadjer, 2001, p. 81*). The claims for such protection are regulated under Arti. 75 and 76 of the PA. The key difference between the two types of protection lies in the fact that possessory protection does not safeguard rights but rather defends possession as a de facto state, as well as detention in the cases outlined in Art. 76 of the PA. A specific distinction must be drawn between possessory and proprietary claims, as they share many similarities. Since the former concerns the protection of a factual situation and the latter involves the protection of property rights, including limited real rights, they are referred to respectively as possessory and petitory claims.

As possessory claims aim to protect possession (and detention under Art. 76 of the PA), and petitory claims serve to protect property rights, the two types of claims may not be joined in a single legal proceeding. However, this does not prevent an owner or the holder of another real right from filing a possessory claim to defend their right to possess the item. A person who has brought a claim of ownership over immovable property may not file a possessory claim against the same defendant for the same property while the ownership case is pending, unless

the possession was taken away after the filing of the ownership claim—either by force or clandestinely (Art. 359 of the CiPC).

Possessory protection is provided through a special legal procedure for the protection and restoration of disturbed possession (Arts. 356–361 of the CiPC). In such cases, the owner does not need to prove that they hold a real right, but merely that they exercised de facto possession and that this possession was disturbed, as the court in these proceedings examines only the fact of possession and its disturbance (Art. 357, para. 1 of the CiPC). The existence of a property right is not necessarily examined. However, documents certifying ownership are taken into consideration only insofar as they establish the fact of possession. In contrast, in a proprietary claim, firstly, no special procedure is provided, and secondly, the claimant must prove that they possess a property right. The burden lies on the claimant to prove their ownership or another real right over the item.

Another difference is that petitory claims are not always condemnatory in nature, while possessory claims always aim for the defendant to be ordered to act or refrain from acting. Claims for the protection of property rights may also be declaratory. Possessory claims must be filed within a six-month limitation period, whereas no such period exists for petitory claims; they are not subject to limitation.

Other civil-law methods of protection include contractual claims, such as claims by a borrower for the return of a loaned item, by a tenant, by a depositary, for tortious damage, unjust enrichment, and others, most of which are based on an existing legal relationship between creditor and debtor.

Criminal protection of property rights can be achieved by criminalising certain types of encroachments on property. Crimes against property are regulated in Chapter V of the Special Part of the CC. Criminal protection may be divided into two main groups:

Protection against deprivation of possession from the owner. This group includes theft, robbery, embezzlement, and concealment of property.

Protection against damage to another's property, such as destruction, damage, and abuse of trust.

These can also be classified based on whether the perpetrator exercises possession at the time of committing the act. In one case, the perpetrator removes possession and the act of removal is part of the criminal conduct—e.g., theft and robbery. In the other, the perpetrator already exercises possession prior to the act—e.g., embezzlement.

The protected legal interest comprises two groups of societal relations: property relations and those ensuring the normal exercise of property rights (*Stoinov, 2021*). The object of these crimes may be both movable and immovable property, but certain offences involve the unlawful taking of only movable items—such as theft and robbery. In all such cases, the offence must involve a tangible object or property right assessable in monetary terms. In other words, there is always a property interest, which is a key characteristic of property rights.

Administrative protection is that which is implemented through administrative procedures. Its significance has increased over time. A classic example is the protection of state and municipal property under Art. 80 of the SPA and Art. 65, para. 1 of the MPA.

Properties owned by the state or municipalities that are held or used without legal grounds, used contrary to their intended purpose, or no longer needed, are subject to repossession by

order of the regional governor, based on a substantiated request by the relevant minister or head of an institution—or by the mayor, in the case of municipal property.

Another example is the protection provided in Art. 52 of the PA, which prohibits planting trees closer than 3 metres for tall trees, 1.5 metres for medium ones, and 1 metre for low ones from the boundary of a neighbour's property. The neighbour may request permission from the mayor of the municipality, district, or settlement to have overhanging branches or roots extending into their property cut. They may also request the relocation of trees planted closer than the specified distances.

A further example is provided in Art. 34, para. 1 of the ALO&UA, according to which, at the request of owners or legal users of agricultural land with restored ownership, the land may be repossessed by order of the mayor of the municipality where the property is located from persons who use it without legal grounds. The land is then handed over to the rightful owners or legal users. To establish the unlawful use, the mayor may officially request information from the State Fund "Agriculture"—Paying Agency, or from its regional structures and/or the municipal agricultural office or the geodesy, cartography, and cadastre office.

Judicial and Extrajudicial Protection

The distinction between judicial and extrajudicial protection is based on whether the protection is performed with the assistance of a court.

Extrajudicial protection may be exercised by administrative authorities through administrative procedures. Such protection does not require court involvement. To some extent, extrajudicial protection corresponds to administrative protection, which was discussed earlier, but not all extrajudicial means of protection are examples of administrative protection. Viewed more broadly, extrajudicial protection also includes certain limitations established by law itself. An example can be found in Art. 86 of the PA, which stipulates that property that is public state or municipal ownership cannot be acquired by prescription. The rationale is that public state and municipal property serves to satisfy public interest. More importantly, this type of property is protected against acquisition by prescription directly by law.

Judicial protection is that which is performed with the assistance of a court. In all cases, protection provided by criminal law is judicial—criminal law protection. Civil law protection is also judicial—all claims brought by the owner, whether they are contractual or property law claims.

Protection According to the Subject Matter

There are cases where the state and municipalities are placed in a privileged position regarding the protection of their property compared to citizens and legal entities. With this in mind, protection can be classified as protection of state and municipal property and protection of ordinary private property of citizens and legal persons.

This is the case in the scenarios of Art. 80 of the SPA and Art. 65, paragraph 1 of the MPA. Properties that are state or municipal ownership, which are held or possessed without legal basis, used improperly, or whose necessity has ceased, are confiscated by order of the regional governor, based on a reasoned request from the respective minister or head of the relevant department—in the case of state ownership—or from the mayor of the municipality when the

property is municipal. In this case, the order results in compulsory confiscation of property by administrative means.

For private property, this is not possible; if there is unlawful possession or holding, the citizen or legal entity—the owner—must file a claim under Art. 108 of the PA or a contractual claim if a contract exists, to oblige the defendant to return the item. The difference is that the protection provided under the SPA and MPA applies only to immovable property, whereas a claim under Art. 108 of the PA may be filed for both movable and immovable property. If a movable item—state or municipal property—is unlawfully held or possessed, the state or municipality must file a claim under Art. 108 of the PA.

In private law, the leading principle is equality and, specifically, equality of the parties. In exercising private ownership, all legal subjects, including the state and municipalities, are equal. Therefore, the scope of rights and obligations of the state and municipalities as holders of private ownership cannot fundamentally differ from those of any other private law subject regarding the property owned (*Decision, 2010*). One might question why differences are drawn between private state and municipal ownership and the general regime of private ownership. On one hand, the legislator achieves an equalisation of the protection of private with public state and municipal ownership, which is inadmissible under Art. 17, para. 2 of the Constitution. Additionally, different regimes of protection are established for private state and municipal ownership compared to the general regime of property protection.

On the other hand, the Constitution does not prohibit establishing a different regime regarding private state ownership compared to the general property regime, nor does it forbid providing an identical means of protection as for public property. It is a fact that Art. 17, para. 2 divides ownership into public and private, but this does not oblige the legislator to introduce a completely different protection regime. Moreover, this permission does not apply to all types of protection. An example is the Supreme Court of Cassation Decision No. 3 of 24 February 2022, case No. 16/2021, which declared unconstitutional the provision of §1, paragraph 1 of the Supplementary Law to the PA, which stated that "the prescription period for acquiring property—private state or municipal ownership—shall be suspended until 31 December 2022 inclusive for the acquisition of agricultural land owned by or whose ownership has been restored under the Property and Use of Agricultural Land Act to state or municipal schools or other state and municipal institutions within the pre-school and school education system." This highlighted the difference between private state and municipal ownership in terms of acquisition by prescription, as the prohibition of acquisition by prescription applies only to public ownership.

In summary, taking all of the above into account, it may be concluded that it cannot be absolutised that there is an equalisation of private state and municipal ownership with public ownership on the one hand, and a significant difference from ordinary private ownership on the other. It may be summarised that the measures provided in Art. 80 of the SPA and Art. 65, para. 1 of the MPA emphasise a specificity in the protection regime of private ownership according to its holder, but this in no way means equalisation with the regime of public ownership.

Domestic and International Protection

Protection of property is divided into domestic and international based on the criterion of where the method of protection is regulated.

When the regulation is found in domestic legislation, the protection is classified as domestic. Domestic protection can be found in the provisions of the Property Act, Spatial Development Act, Plant Protection Act, State Property Act, Municipal Property Act, Corporate Income Tax Act, etc.

On the other hand, protection is international when it is regulated not by domestic sources but by international sources and EU law. In a global context, property rights are protected by international instruments such as the Universal Declaration of Human Rights (Art. 17), which recognises the right to property as a fundamental human right; the European Convention on Human Rights and Fundamental Freedoms (Art. 1 of Protocol No. 1), which guarantees protection against unjustified deprivation of property. The case law of the HR European Court in Strasbourg also plays an important role (*Panayotova-Chalkova, 2019*).

EU law also provides protection of property. Art. 17 of the Charter of Fundamental Rights of the EU states that everyone has the right to own, use, dispose of, and bequeath lawfully acquired property. No one may be deprived of their property except in the public interest, in cases and under conditions provided for by law, and against fair and timely compensation for the loss incurred. The use of property may be regulated by law to the extent necessary for the general interest.

Preliminary and Subsequent Protection

The protection of property can be distinguished with regard to whether there is an infringement upon the real right or not, into preliminary and subsequent protection.

In preliminary protection of property, there is no infringement upon the subjective right of ownership. Its aim is to entirely prevent the violation of the right. This is what defines its preliminary nature. This category of protection serves as a prevention against violations. Therefore, preliminary protection can also be described as preventive. It functions as a preventive mechanism that minimises the risk of infringement and creates a stable legal basis for the exercise of the real right. An example of this is the protection of the legal prohibition on acquiring public property by prescription. Another example is the prohibition on acquiring movable property whose possession was obtained through a criminal offence. More broadly, registration (entry in a public register) also provides preventive protection as it ensures publicity.

In contrast, subsequent protection involves an actual violation of the real right. The infringement may also take the form of contesting or denying the existing real right. The essential point is that there is an obstacle to the free exercise of the real right, which gives rise to the need for protection. It can also be defined as substantive protection, since it is applied after the violation has already occurred.

These two categories are mutually complementary. Preliminary protection aims to prevent violations, while subsequent protection is applied to remove violations once they have occurred. In this way, a comprehensive legal framework is ensured, which not only protects the right of ownership but also guarantees its free exercise.

Lawful and Unlawful Protection

Types of protection can also be divided into lawful and unlawful, depending on whether the law permits protection through the respective actions taken. All means of protection regulated by law are performed according to the procedure also stipulated by law, and are therefore lawful. These are the permitted and lawful ways to protect rights. In all cases, protection of property is worth performing through this group of methods.

Opposite to lawful protection are unlawful types of protection. One of the reasons why there are multiple different methods for protecting property is to avoid self-help (vigilantism), which is criminalised under Art. 323 of the PC and is a classic example of unlawful protection. Through self-help, in practice, the rights of the owner may also be protected, but it crosses a different boundary—that of the law. It protects ownership but at the cost of committing a crime. Therefore, this is unlawful protection of property. It is prohibited by law, specifically by the PC. The legislator has determined that the degree of social danger is so high that self-help must be criminalised. In this case, priority is given to order and public peace rather than allowing the rights-holder to take unilateral actions that do not correspond with the order established by law. Self-help, besides affecting order and public peace, also undermines the established public order for legitimate dispute resolution between citizens and legal entities. This is done through the assistance of competent authorities. Any unilateral action performed in violation of the legally established procedure also constitutes an attack on the authority of justice, as it is not permitted to usurp the functions of the judiciary in resolving legal disputes.

Discussion

The legal protection of the right of ownership remains a central topic in legal discourse, especially in the context of dynamic socio-economic changes and the growing influence of international law. The present study shows that existing legal mechanisms provide a solid foundation for the protection of property. Nevertheless, emerging challenges require the modernisation of the legal framework to ensure its effectiveness in conditions of digitalisation and globalisation.

One of the key aspects of the discussion is the balance between private property rights and the public interest. This requires careful analysis of legal measures that restrict the right of ownership to ensure they are necessary and proportionate to the objectives pursued. In this regard, future research should focus on developing criteria for assessing the proportionality of such measures.

Another important aspect is the protection of virtual assets in the context of digitalisation. Traditional legal mechanisms, such as vindicatory and negatory claims, are not always suitable for resolving disputes related to digital assets. This necessitates the development of new legal instruments tailored to the specifics of the digital environment. At the same time, it is necessary to ensure that these new mechanisms do not infringe owners' rights or create additional barriers to access to legal protection.

The efficiency of the judicial system is also a subject of discussion. Lengthy and costly court proceedings may hinder citizens' access to legal protection, highlighting the need to introduce alternative dispute resolution methods, such as mediation and arbitration. These methods can

contribute to quicker and more effective resolution of conflicts related to property while reducing the burden on the judicial system.

International standards, particularly those of the HR European Convention and its protocols, as well as EU law, play a key role in the development of national legislation. They promote compliance with the principles of fairness, proportionality, and protection of owners' rights. However, harmonising national legislation with international standards requires a careful and professional approach.

In conclusion, the protection of the right of ownership is a dynamic and multifaceted process that requires continuous adaptation to changing social, economic, and technological realities. Future research should focus on developing new legal mechanisms that respond to contemporary challenges, as well as on improving the effectiveness of existing tools for property protection.

Conclusion

The protection of the right of ownership, as a fundamental element of the rule of law, is implemented through a complex system of legal mechanisms reflecting both historical context and contemporary challenges. The constitutional principle of inviolability of private property (Art. 17, para. 3 of the Constitution) and guarantees of equal treatment of all types of property (Art. 2, para. 2 of the PA) form the basis of the legal framework protecting the absolute character of this right. However, the right of ownership is not absolutely unlimited—it may be restricted voluntarily or compulsorily, provided that this is necessary to protect higher legal values or public interests (Art. 17, para. 5 of the Constitution).

Analysis of legislation and judicial practice, including Constitutional Court decisions, demonstrates that property protection is performed through various groups of mechanisms classified into different categories.

The dynamics of socio-economic and technological changes necessitate adaptation of traditional mechanisms. The increasing role of digital assets and virtual property requires the development of specialised legal tools that respond to new developments in various forms of ownership without compromising established principles. International legal standards, notably the HR European Convention, including the European Court of Human Rights' practice, and EU law contribute to the harmonisation of national legislation by emphasising proportionality and fairness in restricting rights.

Despite the resilience of classical methods (such as vindicatory and negatory claims), modern conditions demand improvement of judicial procedures and introduction of alternative dispute resolution methods. The balance between protecting private interests and public needs remains a key challenge, especially in the context of public ownership and compulsory expropriations.

In conclusion, property protection is a dynamic legal figure whose effectiveness depends on the ability of the legislator and law enforcement bodies to integrate traditional principles into new realities, ensuring both the stability of legal relationships and compliance with international human rights standards.

Conflict of Interest

The author declares that there is no conflict of interest.

References:

Andreev, M. (1993). *Roman Private Law*. Sofia: Sofi-R. (In Bul.). [Андреев, М. Римско частно право. София: Софи-Р, 1993.]

Boyanov, G. (2014). *Property Law* (8th ed.). Sofia: Avalon. (In Bul.). [Боянов, Г. Вещно право (8 изд.). София: Авалон, 2014.]

Cherneva, B., Kiselova, N., Draganov, Zh., Mitreva, P., & Hadzhiyska, A. (2023). *Protection of fundamental rights. Lecture course*. Sofia: Siela Norma AD. (In Bul.). [Чернева, Б., Киселова, Н., Драганов, Ж., Митрева, П., Хаджийска, А. Защита на основните права. Курс лекции. София: Сиела Норма АД, 2023.]

Decision No. 15 dated 2010 of the Supreme Court of Cassationcase. Case No. 9/2010.

Decision No. 17 dated November 04, 2021 of the Constitutional Court of the Republic of Bulgaria in Constitutional. Case No. 11/2021.

Drumeva, E. (2018). *Constitutional Law* (5th ed.). Sofia: Siela Norma AD. (In Bul.). [Друмева, Е. Конституционно право (5 изд.). София: Сиела Норма АД, 2018.]

Dzherov, A. (2010). *Property Law*. Sofia: Siela. (In Bul.). [Джеров, А. Вещно право. София: Сиела, 2010.]

Panayotova-Chalkova, L. (2019). *Ownership – development and perspectives. Influence of Constitutional and European Case Law*. Sofia: Siela Norma AD. (In Bul.). [Панайотова-Чалъкова, Л. Собственост – развитие и перспективи. Влияние на конституционната и европейската съдебна практика. София: Сиела Норма АД, 2019.]

Pavlova, M. (2002). *Civil Law – general part*. Sofia: Sofi-R. (In Bul.). [Павлова, М. Гражданско право – обща част. София: Софи-Р, 2002.]

Stalev, Zh., Mingova, A., Popova, V., Stamboliev, O., & Ivanova, R. (2020). *Bulgarian Civil Procedural Law* (10th ed.). Sofia: Siela Norma AD. (In Bul.). [Сталев, Ж., Мингова, А., Попова, В., Стамболиев, О., Иванова, Р. Българско гражданско процесуално право (10 изд.). София: Сиела Норма АД, 2020.]

Stoinov, A. (2021). *Criminal Law. Special part. Crimes against property*. Sofia: Siela. (In Bul.). [Стойнов, А. Наказателно право. Особена част. Престъпления против собствеността. София: Сиела, 2021.]

Stoyanov, V. (2024). *Property Law*. Sofia: Trud and Pravo. (In Bul.). [Стоянов, В. Вещно право. София: ИК „Труд и право“, 2024.]

Tadjer, V. (1975). *Law of State Socialist Property*. Sofia: Nauka and Izkustvo. (In Bul.). [Таджер, В. Правото на държавна социалистическа собственост. София: Наука и изкуство, 1975.]

Tadjer, V. (2001). *Property Law of the Republic of Bulgaria. Part four. Possession* (3rd ed.). Sofia: Sofi-R. (In Bul.). [Таджер, В. Вещно право на Република България. Част четвърта. Владение (3 изд.). София: Софи-Р, 2001.]

Venedikov, P. (1991). *The system of Bulgarian Property Law*. Sofia: Grafik 7M. (In Bul.). [Венедиков, П. Система на българското вещно право. София: График 7М, 1991.]

Grigoriu, I. [a][14]

MEANING, RELATION, IDENTITY AND GENERALITY IN THE TRACTARIAN PHYLOSOPHY [7]

Abstract: In this article, I examine the theory of representation (representationalism) in *Tractatus Logico-Philosophicus*, considering it as a means of access to the Tractarian architectonics. I focus on the introduction of a new formalism specific to Wittgenstein, designed to establish conceptual writing on different foundations than those of Frege–Russell, to avoid inherent paradoxes and to eliminate the cumbersome techniques used to counter them. In this regard, I analyze and interpret Wittgenstein's new formalism for eliminating metalanguage and the theory of types, comparing Frege's theory of sense and reference with Wittgenstein's proposal, which separates meaning from the way an object appears and distinguishes between syntax and semantics—a critique that also applies to Russell. Wittgenstein's approach to "cutting through" these issues is to assert that the propositional sign cannot state or show anything about itself. By following the logicality of the image and the concrete way it is constituted, Wittgenstein constructs his formalism of general forms concerning relations, operations, propositions, and logical functions. Through this framework, he defines, in a logicist manner, the concept of the general form of a proposition, logical operations, and natural numbers. All these are intensional forms, obtained by highlighting their internal structures. In this way, the Austrian philosopher exposes an entire series of metaphysical expressions associated with foundational theories of numbers, constructions, and calculative conventions, as well as with the logicist foundations of mathematics (set, function, number, conventional signs). It becomes evident that mathematics and logic share the same internal structures, and logical discoveries are reflected at the level of mathematical language. As part of this process, Wittgenstein eliminates the concept of identity as expressed by the equality sign, replaces the universal quantifier with the existential one (using negation and an additional variable), and introduces his formal notation. Through these modifications, he attempts to eliminate the "pseudopropositions" that undermine the logicist edifice of mathematics. This article also examines how Wittgenstein reformulates Russell's concept of relation from *Principia Mathematica*, assimilating it into an empirical framework. In this case, Wittgenstein reduces the symbolism of relations to states of affairs, with the direction being from objects to relations rather than vice versa. I emphasize that Wittgenstein equates relations with the concept of logical operations, thereby ensuring the necessary generality and reconstructing the general form of the concept *aRb*. The author synthesizes the general forms presented in the *Tractatus*: relation, proposition, series of forms, natural number, and the derivation of one term from another based on the internal relation of a series of forms. The central aim of this study is a comparative reconstruction of how Wittgenstein proposes replacement theories for the formalisms of Frege and Russell/Whitehead, as well as a new reading of the *Tractatus Logico-Philosophicus* from the perspective of the theory of meaning and general forms, with a focus on the sentences contained in sections 5.53–5.54.

Keywords: representationalism, meaning, relation/logical operation, identity, internal forms and structures, general forms, Tractatus Logico-Philosophicus.

Introduction

The interpretation of meaning within the framework of Wittgenstein's philosophy remains a central issue in contemporary philosophical inquiry, particularly in relation to the Tractatus Logico-Philosophicus and its dialogue with the traditions of Frege and Russell. The relevance of this topic stems from the persistent need to clarify the foundations of logic, mathematics,

[a] Iulian Grigoriu, Ph.D. Student, "Dunarea de Jos" University of Galati. Galaţi, Romania. E-mail: iulian_grigoriu@yahoo.com

and language in order to address paradoxes, ambiguities, and conceptual confusions that have shaped modern thought. Representationalism, as a general conception of meaning, provides a fruitful perspective for investigating these problems, since it highlights the intricate interplay between reality and its symbolic or linguistic representation. The continued scholarly debate concerning the limits of representation, the nature of logical form, and the relation between signs and objects confirms the significance of this research both within the historical study of analytic philosophy and for broader epistemological considerations.

The novelty of the present study lies in its systematic reinterpretation of Wittgenstein's representationalism as an anti-descriptive, multi-layered notion that transcends the conventional dichotomy between language and reality. By emphasising the performative and manifestative dimensions of representation—"to show", "to depict", "to generalise", "to stage"—the analysis expands beyond the classical descriptive paradigm. Moreover, the study situates Wittgenstein's thought within a dynamic field of tension involving Frege's logicism, Russell's theory of types, and subsequent developments in symbolic logic and the philosophy of mathematics. This innovative perspective challenges the inherited categories of meaning and identity, proposing instead a conceptual framework in which logic and mathematics reveal their representational structures without reliance on external descriptive foundations.

The object of the study is the general theory of meaning and representation in the philosophy of logic, mathematics, and language.

The subject of the study is Wittgenstein's conception of representationalism, particularly as developed in the Tractatus and contrasted with the theories of Frege and Russell. In this regard, representationalism is examined not merely as a historical doctrine but as a methodological and conceptual tool for clarifying the logical underpinnings of thought and discourse.

The purpose of the study is to demonstrate how Wittgenstein's representationalism reconfigures the relationship between language, logic, and mathematics, offering an alternative to both Frege's semantics and Russell's formalism. The study aims to show that Wittgenstein's elimination of identity, the universal quantifier, and the equal sign from conceptual notation is not an arbitrary gesture but a coherent strategy designed to preserve the autonomy, internal consistency, and transcendental necessity of logical representation.

To achieve this purpose, several tasks are defined:

- analyse the core principles of representationalism in the Tractatus and their implications for the theory of meaning;
- reconstruct Wittgenstein's dialogue with Frege and Russell, identifying points of convergence, critique, and divergence;
- explore the methodological innovations introduced by Wittgenstein, such as the elimination of pseudo-propositions, the reconfiguration of quantifiers, and the definition of numbers through operations;
- evaluate the broader philosophical significance of representationalism for understanding the unity of logic and mathematics, as well as its implications for the philosophy of language;

– situate Wittgenstein's contribution within the larger trajectory of analytic philosophy, highlighting its enduring relevance for current debates on representation, truth, and the limits of expression.

In summary, the study sets out to clarify and advance the discussion on representationalism as a pivotal concept in Wittgenstein's thought. By addressing the problems of meaning, identity, and relation in dialogue with his predecessors, the research aims not only to interpret Wittgenstein's philosophical project but also to reveal its potential to inform contemporary approaches to logic, mathematics, and language.

Materials

The present study draws upon a set of seminal works in philosophy, logic, and mathematics, complemented by recent scholarly contributions that contextualize Wittgenstein's representationalism. These sources provide both the historical foundations and the interpretative frameworks necessary for addressing the questions of meaning, identity, and representation.

A cornerstone of this research is Gottlieb Frege's classic essay Sense and Reference (*Frege, 1948*), which introduces the distinction between the sense (Sinn) and reference (Bedeutung) of linguistic expressions. Frege's conceptual framework remains crucial for understanding Wittgenstein's early philosophy, particularly the Tractarian distinction between meaning, truth-value, and logical form. Frege's later work, The Foundations of Arithmetic (*Frege, 1950/1960*), further develops a logicist approach to mathematics, arguing that numbers are logical objects. This work serves as a background against which Wittgenstein formulates both his acceptance and rejection of logicist principles.

The study also makes use of Russell and Whitehead's monumental Principia Mathematica (*Russell & Whitehead, 1925–1968*), a foundational text in modern logic and mathematics. While the work aims to reduce mathematics to logical axioms and rules, Wittgenstein's critique of its formalism and the theory of types illuminates the originality of his representationalism. The Principia provides the technical framework against which Wittgenstein formulates his rejection of unnecessary formal structures and his insistence on the autonomy of logical syntax.

Central to the analysis are the various editions and translations of Wittgenstein's Tractatus Logico-Philosophicus. The English translation by Pears and McGuinness (*Wittgenstein, 1961*; *Wittgenstein, 1974*) has played a pivotal role in disseminating Wittgenstein's ideas to an international audience, while the German edition included in Schriften I (*Wittgenstein, 1969*) remains a standard reference for textual accuracy. These works not only establish the textual basis of the inquiry but also highlight interpretative nuances related to translation and terminology.

Recent secondary literature by Iulian Grigoriu provides a detailed and innovative analysis of representationalism. In Tractatus Logico-Philosophicus—Internal and External Contradictions, and Translation Issues (*Grigoriu, 2017a*), the author examines tensions within the Tractatus, paying particular attention to problems of coherence and translation. Logic Universe Generator (*Grigoriu, 2017b*) advances a novel interpretation of Wittgenstein's conception of the general form of propositions, presenting the idea of "bidimensional logic" as a tool for understanding logical structures. In Prolegomena for a Philosophy of Mathematic

(*Grigoriu, 2017c*), Grigoriu investigates the philosophical underpinnings of mathematics, highlighting continuities and ruptures with the Wittgensteinian tradition.

In his subsequent work, Philosophy of Logic and Logicist Failure in the Tractatus Logico-Philosophicus (*Grigoriu, 2018*), Grigoriu critiques logicism in the light of Wittgenstein's philosophy, showing how representationalism offers an alternative approach to the foundations of mathematics. Wittgenstein's Philosophy Elements of Mathematics in the Ideal Space of the Thirties (*Grigoriu, 2019a*) situates Wittgenstein's reflections within the broader intellectual climate of the 1930s, linking them to developments in the philosophy of mathematics and logic. Collectively, these contributions provide fresh insights into the originality and complexity of Wittgenstein's representationalism, while also identifying unresolved issues that invite further inquiry.

Taken together, these materials form a coherent corpus that bridges the classical tradition of logic and mathematics with contemporary reinterpretations of Wittgenstein's philosophy. Frege and Russell provide the necessary historical and conceptual foundations, Wittgenstein himself formulates the philosophical breakthrough of representationalism, and Grigoriu's works offer detailed exegesis and theoretical innovation. This combination of primary and secondary sources ensures both historical accuracy and conceptual depth, allowing the present study to articulate a nuanced understanding of meaning, identity, and representation in the context of Wittgenstein's philosophy.

Result

Representationalism—General Conception of Meaning

The concepts of meaning, relation, and identity are part of a broader theory of representation (of images or pictures) that I call representationalism.

Representationalism is a general conception or attitude toward meaning, as it was for Leibniz, Kant, Schopenhauer, and Hertz. It is also an element of continuity (between early Wittgenstein, mature Wittgenstein, and late Wittgenstein) and a unifying factor across the fundamental fields of Wittgensteinian philosophy (philosophy of logic, philosophy of mathematics, and philosophy of language).

In all fields of Wittgensteinian philosophy, the discursive-conceptual approach is based on a trans-metaphysical tension between reality and representation. Reality, or the world, tends toward symbols and concepts, and the image of the world holds explanatory power. "To understand", "to highlight", "to show", "to say", "to criticize", "to calculate"—and all that these imply in the practice of "language games"—are part of a téchné and respond to a transcendental necessity.

The possibility of representing something is transcendental; it is related to the unity of subject and object. However, for Wittgenstein, this unity does not originate from an unknowable source (as in Kant's thing-in-itself), but rather from Schopenhauer's concept of will or from a connection with the absolute, as in German idealism.

In my related works (*Grigoriu, 2017a*; *Grigoriu, 2017b*; *Grigoriu, 2017c*; *Grigoriu, 2018*; *Grigoriu, 2019*), I show that representationalism is an anti-descriptive term with the simultaneous meanings of "to show", "to depict", "to generalize", and "to stage". Wittgenstein employs

several expressions with this last meaning (darstellen, abbilden, vorstellen), offering an intuitive framework for the targeted fields (language, logic, and mathematics).

In the Tractatus, representationalism is linked to the similarity between thought and its logical expression; its basis is the logical space. Logic can be regarded as a representational foundation because it shows rather than describes itself—just as a play or an artistic act unfolds on a stage where the entire universe is allocated to the artistic act itself, while the rest of the world remains strictly delineated. It is not as though a spectator must step onto the stage to save Desdemona's or Juliet's life—an absurdity akin to the situation of those who take language paradoxes literally.

In Wittgenstein's philosophy after the Tractatus, representationalism becomes the manifestation and revelation of linguistic, logical, and mathematical phenomena, aiming to capture their conventional nature, techniques, rules, and preeminence, with the logical space evolving into a more complex and nuanced grammatical space.

In the equation natural language—logic—mathematics, representationalism consists of the process by which I extract, eliminate, and separate natural language from logic and mathematics so that logic and mathematics may express themselves in their distinct languages and natures. This implies direct access to a sign language that is autonomous, consistent, coherent, and free from contradictions and paradoxes.

If, in the Tractatus, the goal of representationalism was to purify and disentangle thinking (logic and mathematics) from the distortions of natural language (4.002c), then in his later research, Wittgenstein exposes mathematical techniques as being irreversibly shaped by linguistic structures. Underneath the eccentricity and exoticism of these structures, however, lies a living body.

Tractarian Representationalism

Representation theory (2.1–4.128) lays the groundwork for the philosophy of logic and mathematics in the *Tractatus* and contains certain elements of interest here:

- "We picture facts to ourselves" (2.1);
- The image, through its logical form, represents the fact (*Tatsache*), meaning that it connects it to our understanding;
- The logical form is the most general type of form; it constitutes the possibility of states of affairs (*Sachverhalten*) in the logical space (2.18, 2.201, 2.202);
- The image (logical—2.182) represents the world or an aspect of the world;
- The sense of the image (2.221) is related to the truth or falsity of the image (2.222, 2.223);
- An image is not true a priori (2.225) but only in relation to reality;
- From (3), the notion of "thought" arises: "A logical picture of facts is a thought," so that 3.12 states that the sign of thought is the proposition (*Satzzeichen*—propositional sign); hence, the theory of the sign and proposition is related to their use up to 3.5, followed by a discussion on thinking (4), language, the relation between them, and the possibility of representing reality;
- The image is a situation (*Sachlage*) in logical space, which represents the existence and non-existence of states of affairs;

- Just as there are simple elements of the world (objects), there are simple elements of the image in correspondence with objects, which replicate the logical (not spatial) relations between them;
- The connection between the elements of the image and the corresponding objects determines the structure of the image (2.13, 2.131, 2.15);
- The possibility of structuring the elements of the image constitutes its form of representation, which connects the image to reality (2.1511);
- The image represents reality because its elements reproduce, in their structure, a certain state of affairs; the representational relation belongs to the image (2.1513);
- The image is a fact and, therefore, part of the world (2.141). The "image fact" shares with what it represents a logical form;
- The image does not represent its form of representation but instead shows it (2.172)—a defining element of representationalism. That is, representation terminates at the image itself;
- Therefore, the image of the "fact-image" occupies a different place in logical space than the image as such.

Observations

(a) The Non-Reproducibility of the Image

A doubt could arise from the fact that an image is a fact, and thus, it could be considered a source of another image (since it belongs to reality). However, the image of this latter fact would be an independent image, not an image of the image. It would occupy a different point in logical space than the first representation.

There is no "image of the image", just as there is no "fact of a fact" or "thought of a thought", as demonstrated by other propositions. The image as fact is not meant to be represented again, just as a play does not become a fact for a script of a script. Instead, the latter is simply another script for another fact.

An image of the image is nonsensical when it refers to the same fact represented, though it is not prohibited for the same fact to allow different images.

(b) The Economy of Logical Representation

Two logical images of the same fact should be equivalent, following the representationalist imperative that the most "economical" image (Occam's razor) prevails. The essential requirement is that any image must be logical, meaning that it must share a logical form with the represented reality. This guarantees the economy of representation.

The goal is to prevent an infinite proliferation of "an image of an image", and so on. In this sense—but somewhat indirectly—4.04 and 4.041 state that a proposition, as an image of facts, must have the same number of parts (or multiplicity) as the state of affairs it represents: "This mathematical multiplicity, of course, cannot itself be the subject of depiction. One cannot get away from it when depicting." (4.041)

Moreover, 3.14 states that the propositional sign (the means by which thought is expressed) is itself a fact. An analogy emerges between image and proposition (logically identical): just as the elements of an image relate to each other in a determined manner (2.15), the elements of the propositional sign—the words—"stand in a determinate relation to one another" (3.14).

(c) The Counter-Descriptive Nature of the Picture

Another element of representationalism is that a picture cannot describe its form but instead shows it. The picture is not a description of its form but rather a manifestation. This allows us to understand:

- On the one hand, that representation is distinct from the representational;
- On the other, that a fact may be represented with varying degrees of proximity to reality, depending on how the logical form is incorporated.

Thus, we are assured that logical pictures can represent the world (2.19). However, it can be suggested that sensory pictures make representation problematic. In any case, the logic of pictures must be rationally grasped through representation techniques:

- Logical representation is infallible and serves as the criterion for other representations.
- That is, any picture is logical (2.182), meaning it represents reality and has no alternative.

(d) The Metaphysical Nature of Statement 2.182.

Statement 2.182, which asserts that "any picture is logical, but not necessarily spatial", is metaphysical for the following reasons:

- It presupposes that any picture carries within it a symbolic or conceptual logic, which implies that logical representation pre-exists the object itself, prior to any thought or sensation. For Kant, this would correspond to pure intuition or apperception, which does not belong to sensory perception.
- This could also suggest that the sensible world can be reduced to the intelligible world and possesses an intellectual character, i.e., the (logical) picture relates to proposition and negation in its relation to the world, whereas space does not: "Not every picture is spatial" (2.182), even though mathematical analysis, algebra, and geometry operate in such a way that they structure the mathematical world as Hilbert Space, Vector Space, Phase Space, etc.

This statement pertains to Logical Space, a dimensionless, a priori unfolded space containing the foundation of significance for any possible logical universe (in analogy with the ideality of Cartesian orthogonal geometric space, where concepts such as "logical place" and "logical coordinates" are discussed).

The meaning of statement 2.182 is analogous to saying: "It is not necessary for these people to speak to each other; they understand each other merely by glances, intuiting each other's statements, questions, and answers."

Between Frege and Russell

In the *Tractatus*, Wittgenstein makes both explicit and implicit references to Frege's and Russell/Whitehead's theories of meaning. In some cases, he adopts their concepts, while in others, he discusses them in his terms. Although the main propositions of the *Tractatus* (not only those denoted by integers) express his theory, certain considerations in the sub-propositions appear abrupt and radical, requiring further explanation for the reader.

Wittgenstein sometimes criticizes Frege and Russell collectively, while at other times addressing them separately. Adopting their terminology does not imply agreement. When Wittgenstein refers to them implicitly, it can generally be inferred that he has Frege in mind when discussing thought, sign, sense, symbol, meaning, object, and concept, whereas he refers

to Russell when discussing propositional atoms, propositional and functional meaning, relation, identity, truth values, and, of course, the theory of types and the axioms of infinity and reducibility.

The common concepts of name, object, relation, identity, equality, sign, symbol, meaning, and sense acquire different roles in Wittgensteinian representationalism.

Wittgenstein adopts the concept of a proposition as a function of the names and expressions it contains (3.318), as well as the idea of a conceptual notation meant to eliminate the confusions and paradoxes of ordinary language. The paradoxes that Frege and Russell encountered in their foundational work on class theory arise from the misuse of general terms (*object, function, number*, etc.), which should be represented in a conceptual notation through variables rather than functions or classes, as their predecessors had done (4.1272).

The establishment of basic logical operations is merely a matter of notation, reflecting a certain mathematical multiplicity and rule, but they are not fundamental in themselves (5.474, 5.475, 5.476).

Thus, it is impossible to introduce both objects belonging to a formal concept and the formal concept itself as primitive ideas. For example, it is impossible to introduce both the concept of a function and specific functions, as Russell does, or the concept of number and particular numbers (4.12721).

Logic is a domain of a priori thought, admitting totally generalized forms that stand in contrast to generalized forms of an empirical type and to the theory of representation, where names are allocated to objects (cf. 5.526).

Wittgenstein rejects certain key elements from *Principia Mathematica*, including symbolism, formalism, the logic of predicates, the concepts of relation and identity, and the idea of logical objects and constants (5.32; 5.4).

Wittgenstein appears to be critical of a certain style of theorizing in *Principia Mathematica*, where Russell and Whitehead introduce definitions and even fundamental laws without fully understanding their consequences or providing the necessary justifications. As a result, the validity of such principles is questionable. Wittgenstein asserts that logic does not require proof, precisely because logic is a priori, and, in fact, we cannot think illogically (5.4731).

A key element of Wittgenstein's argument against classical logic—and in anticipation of the new vision of language in *Philosophical Investigations*—is the idea that any proposition has meaning, provided that the names it contains have been assigned meaning. This stands in contrast to Frege, for whom meaning is determined by the correct composition of the proposition.

For Wittgenstein, logic is a priori and does not require laws to constitute it, but rather a process of deciphering, to conform to the inherent logic of any structured language.

Wittgenstein criticizes his predecessors for their attitude toward logic, particularly their tendency to treat evidence as a mark of simplicity. From this perspective, neither *modus ponens* nor *the rule of substitution* works automatically, because they use in hypotheses symbols that will appear in the conclusion. This is problematic, especially when it comes to fundamental laws. Either logic has a single fundamental law, or, if it has multiple fundamental laws, they can be combined into a single principle through logical conjunction. This final formulation of the logical principle may be highly complex, but that does not disqualify it as fundamental.

To illustrate the primacy of logic, Wittgenstein offers a metaphor: "Logic is not a body of doctrine, but a mirror-image of the world. Logic is transcendental." (6.13)

When analyzing Russell's theory of types and descriptions (which subsumes Frege's theory of sense and reference), Wittgenstein separates the meaning of a name or sentence from the way the name appears in a proposition.

The rules governing the signs of a proposition (syntax) should not refer to their meaning (their truth value relative to an object in reality). Wittgenstein thus distinguishes the two domains of classical logic without integrating them into a mutual foundation, thereby exposing Russell's error in the theory of types:

"It can be seen that Russell must be wrong, because he had to mention the meaning of signs when establishing the rules for them." (3.331)

"No proposition can make a statement about itself, because a propositional sign cannot be contained in itself (that is the whole of the Theory of Types)." (3.332)

Classical logic permits paradoxes because it allows a propositional function to become its argument. However, the same does not apply to logical operations, which can become their arguments without generating contradictions. This distinction enables Wittgenstein to advance a series of logical forms, culminating in the generalization of the propositional sign and the discovery of the general form of number.

When Frege defines the concept of a natural number, he relies on an entire structure of logical and mathematical notions, including object, meaning, reference, concept, class, property, proper name, common name, identity, equality, discernibility, and substitutability.

Frege's definition of natural numbers is structured as follows:

"The number of concept F is the extension of the concept equinumeric with the concept F."

"The number that belongs to the concept F is the extension of the concept 'equal to the concept'." (*Frege, 1950/1960, par. 68*)

The process of defining particular numbers is connected to the possibility of these extensions being identical or arranged in an ordered structure. With this in place, Frege defines natural numbers:

"0 is the number that belongs to the concept 'non-identical with itself'." (*Frege, 1950/1960, par. 74*)

The concept of "non-identical with itself" does not correspond to any object. Frege argues that no object falls under a concept that contains a logical contradiction. If "a" falls under the concept of "non-identical with itself", then "a" is not identical to "a", which defines the number 0.

Frege then defines the successor function, from which the number "1" and, consequently, the sequence of natural numbers is derived.

In *Principia Mathematica*, the cardinal number "1" is defined as "the class of all unitary classes" (*Russell & Whitehead, 1925-27/1968, (I), p. 363*). The definition of number thus requires set theory supplemented with the theory of types, to avoid semantic paradoxes.

Wittgenstein's critique of Russell unfolds in three dimensions:

1. The theory of types and the axiom of reducibility are unnecessary.
2. The theory of types still generates paradoxes.

3. Wittgenstein develops his formalism of general forms (relation, operation, proposition, logical function), allowing him to define, in a logicist manner, his concepts of function and natural number.

Interpretation of Meaning in Principia and Reaction from the Tractatus

Russell introduces the concept of meaning in the context of discussing propositional functions, which must avoid vicious circles through an appropriate definition. The concept of a function is well defined when its values are well defined, meaning that they do not refer to the function itself—thus avoiding vicious circles and the emergence of paradoxes.

The concept of a function itself remains ambiguous. As Russell states, a function ambiguously denotes the totality of its values, and those that do not refer to the function itself constitute the allowed values of the function (*Russell & Whitehead, 1925-27/1968, (I), p. 38*).

Russell introduces two notations, $\phi(x)$ which denotes the indeterminate value of the function, or the function in general and $\phi(\hat{x})$, the function as such, i.e., the concrete values of the function; here $\phi(\hat{x})$ ambiguously signifies its indefinite value $\phi(x)$.

Thus $\phi(\hat{x})$ ambiguously signifies the ϕx, and $\phi(x)$ is ambiguously denoted by $\phi(\hat{x})$.

Russell also refers to the arguments "x" for which $\phi(\hat{x})$ has value, the possible values of "x". It can be said that: (x) $\phi(x)$ assumes $\phi(x)$ and (Ex) $\phi(x)$ assumes $\phi(\hat{x})$.

It is therefore notable that the concrete values of the function, $\phi(\hat{x})$ play an overlapping role in the process of meaning: on the one hand $\phi(\hat{x})$ ambiguously signifies $\phi(x)$, on the other hand, it signifies the argument "x" if it admits values for the respective arguments. (cf. *Ibid.*)

However, Russell does not stop there. He further argues that $\phi(\hat{x})$ does not have to express a proposition, as it is not signifying—meaning that it does not express anything. This is because its values are all propositions of the form $\phi(x)$, and this prevents the emergence of a vicious circle.

For these reasons, the types of truth that belong to a proposition may differ from those of a particular proposition.

Consider the following statements: "x is a proposition" (1) and "x is a propositional function" (2);

Statement (1) is an ambiguous statement about the values of the propositional function (where the ambiguity pertains to the mode of denotation), while statement (2) is a statement about an ambiguity (since the function itself is ambiguous). Thus, the proposition is true regardless of the value of "x", and it ambiguously denotes the values of "x".

To avoid the vicious circle $\phi(\hat{x})$ whose values are propositions of the form $\phi(x)$, must not express a proposition. It is not signifying, meaning that it does not express anything. In this way, the type of falsity that can be attributed to a general proposition differs from that which can be assigned to a particular proposition.

Through this extremely ingenious approach, Russell develops his theory of "a-functions", which are divided into types. The theory of types requires the introduction of the axiom of reducibility, as well as other techniques and concepts—which he later abandons in the second edition of *Principia Mathematica* (partly due to Wittgenstein's influence, as Wittgenstein considers them pseudo-concepts).

However, the Austrian philosopher does not need to follow the entire structure of *Principia Mathematica*, because, in his view, this entire scaffolding can be cut off at the root. Nonetheless, this requires a preliminary agreement in principle. Regarding the general issue of the meaning of language and philosophy, Wittgenstein adopts the critical and analytical stance of his predecessors and credits Russell with good intentions:

All philosophy is a "critique of language". It was Russell who performed the service of showing that the apparent logical form of a proposition need not be its real one. (4.0031)

However, the way in which Russell formulates his program of eliminating misleading appearances leads Wittgenstein to pursue his path, rather than following Russell. For Wittgenstein, Russell's problems and theories are meaningless if they can be avoided altogether.

A first reaction in the *Tractatus* against confusing aspects of the theory of meaning appears in 3.325, where Wittgenstein asserts that within logical syntax: a sign cannot be used for different symbols, nor can it symbolize differently. This is precisely what Frege and Russell attempt to prevent in their conceptual notation, but which they fail to eliminate entirely.

The result of subordinating the unique meaning of the sign, syntax or rules in the logical-linguistic system will lead to the elimination of meaning from the syntax. As a first stage Wittgenstein eliminates the meaning from the logical syntax, because the sign has meaning by itself, i.e., by its use. A sign is uniquely determined by its meaning, which occurs naturally, through use, or even conventionally. A sign cannot have two meanings, nor can two signs signify the same thing. The rules of a system of signs constitute the logical syntax in which each sign already has its meaning subordinated to the syntax; it no longer has to play an additional role in logical syntax. (cf. 3.33). There is no superposition between the sign, its role in syntax and syntax as such. This is an attribute of Wittgenstein's representationalism. The idea of the uniqueness of each object (logical, when viewed logically, not spatio-temporally, for example, or linguistic object—name, expression, proposition, propositional function) is already an established fact and is repeated or reinforced in (5.53), which will avoid the unjustified multiplication of Russellian types.

Identity of object I express by identity of sign, and not by using a sign for identity. Difference of objects I express by difference of signs (5.53).

The problem is not that we must have a unique sign for each object, but that each object must be analyzed to be represented. Since objects are infinite in number, it is inevitable that different objects in language may have the same sign, or that the same sign may stand for different meanings.

For the classification of objects and the avoidance of paradoxes there are needed either classes, sets, type theory, as Frege and Russell do, or definitions and in tensional forms, which Wittgenstein does. His solution is to identify objects, in general, through their internal logical structure and using their formalism, as will see in a moment.

The Question of Identity in *Principia* and *Tractatus* and the Elimination of the Equal Sign

The problem of meaning entails the problem of identity, along with its associated formal symbolism. In *5.53*, Wittgenstein addresses the issue of identity within formal sign language.

He states that "identity is not a relation between objects" (*5.5301*) and provides the following sentence as an example: "(x): fx. ⊃. x = a". What this proposition says is simply that only a satisfies the function f, and not that only things that have a certain relation to a satisfy the function f. (5.5301)

That is, "a" has the quality of satisfying "f", without being in relation to the variable "x", or the variable "x" identifies with "a" when it is the argument of "f", but it is not in relation to "a".

What is sought to be avoided here is the proliferation of the meaning of "x", as the variable of the predicate (f, x) and as the object variable (x, a). But identity is not a relation for entities, because "x" is only "x", (cf. 5.53).

I add that these "x" may appear as arguments in other functions "g" for example without the danger of the vicious circle appearing, when the function "f" is the argument of "g", such as for example "g (f, x) = b".

To avoid vicious circles, Russell introduces limitations to ensure that functions do not refer to all their values. However, when defining the equality of two functions or two sets, we must consider the coincidence of all their values. To maintain the generality of the definition of identity and prevent undesirable situations, Russell develops the Theory of Types, supported by the Axiom of Infinity. In summary, Russell does the following:

The definition of identity "x = y" implies "∅(x) ⊃∅(y)", whatever the function ∅ variable; the function shows that anything true about "x" is true for "y" too. Being a function of ∅ it must be limited so that it does not refer to all the values of ∅. In this hypothesis, if it is considered that "x = a" is a value of ∅ from the above formula, then "x equals a" implies "y equal to a" so "x equals y". At the same time, we have "x equal to a" and "x equal to y" (from "∅(x) ⊃∅(y)"), then "y = a". So "∅(x) ⊃∅(y)" which is a value of Fix, vicious circle. In this hypothesis, if it is considered that "x = a" is a value of ∅ from the above formula, then "x equals a" implies "y equal to a" so "x equals y". At the same time, we have "x equal to a" and "x equal to y" (from "∅(x) ⊃∅(y)"), then "y = a". So "∅(x) ⊃∅(y)" which is a value of ∅(x), vicious circle.

Other limitations are imposed for ∅, Russell says, but other limitations imposed on ∅ could lead to the ∅(x) being true and ∅(y) false so ∅(x) no longer involves ∅(y), which would mean that the identity between "x" and "y" is no longer reached.

To save the definition of identity, Russell will introduce the theory of types and the axiom of reducibility. In this endeavor he will use the equal sign, "=" in the construction and partitioning of types, which is an abuse, in Wittgenstein's opinion.

Wittgenstein's reaction appears at 5.5302 where he states:

Russell's definition of "=" is inadequate, because according to it we cannot say that two objects have all their properties in common. Even if this proposition is never correct, it still has sense. With the corollary, roughly speaking, to say that two things are identical is nonsense, and to say that one thing is identical with itself is to say nothing at all. (5.5303)

This is the moment when Wittgenstein demonstrates how to remove the sign of equality from conceptual writing. To this end, he introduces alternative notations in conceptual writing.

I write that not "f (a,b) . a = b" but "f (a,a)" (or "f (b,b)"). And not "f(a,b) . . ~a = b", but "f(a,b)". (5.531)

So when Wittgenstein writes a function with the arguments "a" and "b", "b" represents "~ a", and, understandably, in a function with three arguments "f (a, b, c)", "c is .~ a. ∧ . ~ b", confirmed by the general form of the function of truth or the generalized propositional sign "$[\bar{p}, \bar{\xi}, N(\bar{\xi})]$" (*Wittgenstein, 1969*).

Also, when "f", "g", "h" represent propositional functions as arguments of the operation "Ω", which can be applied to them, then "Ω(f, g, h)" is "Ω(Ω(f,g), h)", writing that leads to the definition of the natural number according to the occurrences of the operation "Ω".

It seems natural that functions, more precisely logical operations, should be composed in pairs using the logical operation "Ω", which leads to the idea of developing the one-dimensional logical space of truth functions first at the two-dimensional level, resulting in a "two-dimensional logic", and then extending this process to an n-dimensional "logic universe" (*Grigoriu, 2019*).

Because you cannot use different symbols for the same object, "f (a,b)" with "a = b" in Russell's writing becomes at Wittgenstein either "f (a,a)", or "f(b,b)" (cf. 5.531).

Table 1. Same motivation for predicate formulas at 5.532

	Russell's writing	Wittgenstein's writing
a. Predicates with equal variables	'(∃x, y). f (x, y) . x = y'	'(∃x). f (x, x)'
b. Predicates with opposite variables	'(∃x, y). f (x, y) . ~x = y'	'(∃x, y). f (x, y)'
c. Predicates with distinct variables	'(∃x, y). f (x, y)'	'(∃x, y). f (x, y) .V. (∃x). f (x, x)'

a. Because equality is not a relation between the extensions of objects, Wittgenstein proposes a notation that explicitly denotes identity. More precisely, identity is a relation in which the extensional appearance of the external coincidence of two objects transforms into an internal relation of intrinsic properties—i.e., it belongs to the internal structure of objects, which is formally determined by the predicate. The fundamental structure of objects is logical and internal, and it is determinative for each logical object.

b. In conjunction with 5.53, in a predicate with two variables, if the first is "x", the second, "y", designates "~x".

c. To express a predicate function of two variables, Russell's notation allows for the possibility that one variable refers to or identifies with the other—a case that Wittgenstein explicitly addresses (similar to the process described in the first point).

In the last phrase "y" designates "~x", the disjunction ("x. V. ~x") does not change the truth value of the predicate function, being a tautology.

Elimination of the Universal Quantifier

A typical innovation occurs in 5.5321, where one can observe the interaction between universal and existential quantifiers in the context of negation. Wittgenstein eliminates the universal quantifier over the variable "x" by introducing another variable, "y", which designates, as we have seen, "~x", and thereby increases the order of the predicate "f".

In short, "(x)" is replaced by "∃x" and "~(∃x, y)", where "y" stands for "~x".

Table 1. Same motivation for predicate formulas at 5.5321:

	Russell's writing	Wittgenstein's writing
A. "Only a satisfies the function ( )f" (removal of quantifier Universal and "=" sign)	'(x): f x ⊃ x = a'	'(∃x). f x . ⊃. fa : ~ (∃x, y). f x . f y'
B. "Only one x satisfies f( )"	'(x): f x ⊃ x = a'(1)	'(∃x). f x : ~ (∃x, y). f x . f y'

(1) This writing is implied in *Principia Mathematica*.

I think at 5.5321 Wittgenstein shows that in PM there is no difference between "only a satisfies the function f" and "only one x satisfies f". To eliminate this possibility of confusion, Wittgenstein eliminates the universal quantification and the "=" sign of identity. The compromise which is made consists of the tacit designation of "any" other variable, "y" say with "~x", i.e., there is "x" that checks "f", and no other variable "y" verifies "f". (The negation of quantifiers leaves such situations unresolved to this day). Sentence 5,533 concludes the avoidance of equality in conceptual writing.

Elimination of Other Language Habits

a. Sentences 5.534 and 5.535 (with the sub-propositions annotated) become consequences of the above: Expressions such as "a =a"; the relation of transitivity with extensional allure "a = b, b=c." imply a equal "c", are called "pseudo-propositions" that must be removed from conceptual writing; also cause confusion expressions of the following form: "(x) . x = x", "(∃x). x = a" (cf. 5.534); Wittgenstein believes that all problems related to the axiom of *Infinity* are solved and reframes the axiom naturally "…there are infinitely many names with different meanings" (cf. 5.535)

b. It is considered a formal abuse to use the assertorical sign "⊢" in front of a proposition, in order to ensure that it is a proposition, and that the seats allocated to variables are occupied by propositions; so are the expressions "a = a" and "p ⊃ p" (cf. 5.5351).

c. At 5.5352 is shown the ambiguity of the pseudo-proposition "There are no things" with the writing "~ (∃x). x = x" that could also mean that there are things that are non-identical to oneself. Ironically or not, the very principle of identity and, perhaps, the level of its reality is targeted here. General logical forms express the processual nature of the facts of the world, rather than merely an inventory of things.

The above pseudo-expression would imply that there are no f-things, regardless of the predicate "f", as universal quantification in this domain raises insurmountable difficulties. Wittgenstein, starting with the *Tractatus*, exposes a broad spectrum of metaphysical formulations, ranging from "vidences" to conceptual constructions (such as those of cardinal and real numbers), as well as conventions and calculative constructions.

d. Because mathematics and logic have the same general internal bases, (as will be shown below), the identity with the sign of equality is removed from the syntax of mathematics. "It is impossible to assert the identity of meaning of two (mathematical) expressions." (6.2322)

In case of solving an equation Q = 0, the equation passes through several equivalent forms (Q' = 0, Q'' = 0, …), the meaning or the logical form (6.23) remains the same, only the sense of intermediate expressions changes. The identity of meanings as forms does not show the meaning that I find but after solving the equation, so I cannot indicate it in the course of solving it. That is why it can be stated that "Calculation is not an experiment." (6.2331)

General Form of Relation in *Principia* and *Tractatus*

Russell conceives the concept of relations as an empirical one, grounded in perception, where, in addition to the objects in relation, other elements—such as the mind—are involved. He distinguishes between the judgment of perception, which consists of four terms ("a", "R", "b", and the perceiver), and perception itself, which consists of two terms ("aRb" and the perceiver).

In contrast to this "complex" vision, Wittgenstein reduces the symbolism of relation to the state of affairs, stating that instead of "The complex sign "aRb" says that a stands to "b" in the relation "R", we ought to put, that "a" stands to "b" in a certain relation says that aRb." (3.1432)

Wittgenstein moves from objects to Relation, rather than the other way around, because he does not conceive of relation as a sensory complex or an empirical entity that ultimately obscures the objects involved in the relation (*Beziehung*).

The Concept of Relation provides Russell with an opportunity to introduce, in Aristotelian fashion, the concepts of Truth and Falsity relative to a judgment of perception. Specifically, "aRb" is true when an "aRb" complex exists and false when this complex does not exist.

Building upon the concept of relation, Russell first defines general judgments and then particular judgments, distinguishes between the different truth values of elementary and complex general propositions, and emphasizes that even seemingly elementary propositions are connected to complex relations that must be discerned through logical analysis.

Through the techniques discussed above, he seeks to prevent the paradoxes of language by ensuring that neither a proposition nor any part of it refers to the totality or generality of which it is a part.

For Russell, the relation "R" is a general relation of representation when it is expressed as an incomplete symbol (i.e., one that lacks meaning in its right). He gives examples in which different types of propositions—universal or particular—appear: "a in relation R with b" or "a having the quality q", or "a, b and c are in S relation". It must be recognized that all this approach is one in which logic develops, the foundations of the logic of predicates are laid, the relation between universal and existential quantifiers is defined, the negation and disjunction of predicate forms, prenex forms are obtained, etc.

Wittgenstein states that primitive signs (∧,∨,⊃, etc.), because they can express themselves through each other, are not primitive and are not relation (cf. 5.42). In order to find a "primitive" framework well anchored in generality, Wittgenstein will assimilate the "relation" with the "logical operation" in general, of transitioning from one form to another, however, using an operator with concrete meaning, the "N" symbol of multiple negation.

To Wittgenstein, according to 3.1432, the "R" of "aRb" cannot represent all relations, it does not represent the general form of the relations. This is evident from 4.1273 where I believe that Wittgenstein discovers the vicious circle in the so-called general form "aRb", regardless of the content of "R" (at 4.1273 "R" is custom as denoting the succession relation). In this case, if to the string of forms "aRb, (∃x) : aRx. xRb, (∃x, y) : aRx. xRy. yRb. etc." we associate the general term of "aRb", then we see that it appears in the initial string, so the general form of the relation would appear as a term in a particular sequence, which leads to a vicious circle. Such preoccupations will be represented throughout the Wittgensteinian philosophy of mathematics,

such as the problem of induction, the demonstrations by recursion where the same "vicious" practices are discovered, the fact that the transition from the so-called general to the particular forms is not justified, the demonstrations with general forms at most justify their particular applications as rules or definitions, and are pseudo-propositions outside of the truth and the falsehood. Just as Wittgenstein refuses to write "a = a", he will also refuse to write "aRa". It also follows that identity is not a relation in that it does not imply a relation between objects, as the relation implies, but between the object and itself, which is absurd and therefore the equal sign does not make sense, neither between different objects, because they are different, nor between an object and itself (I cannot make of an object, two, just to put them in relation).

General Forms in *Tractatus*: Relation, Proposition, Series of Forms, Natural Number

Wittgenstein does not give up the general form of relation, but this does not emerge from a perception analysis, it is not the external relation between objects, but an internal one, which is not a proper relation; internal relations are related to the internal structure of the states of affairs, cannot be affirmed by propositions, they are shown (4.122). Therefore, Wittgenstein will represent the general form of the relation as a variable, part of the formula of a formal concept (4.1273, 5.2522), the relation being assumed by the logical operation "O".

The internal relation by which a series is ordered, is equivalent to the operation that produces one term from another. (5.232)

Table 3. Formal representations of generality

a.	The general term of the series of forms (as variable) (5.2522)	[*a*, *x*, *O'x*]
b.	The general form (variable) of a proposition (6)	$[\bar{p}, \bar{\xi}, N(\bar{\xi})]$
c.	The general form of action of an operation (6.01)	$\Omega'(\bar{\eta}) = [\bar{\xi}, N(\bar{\xi})]'(\bar{\eta}) = [\bar{\xi}, \bar{\eta}, N(\bar{\xi})]$
d.	A general form of some series of forms (cf. 4.1273 – 6.02)	$[x, \xi, \Omega'\xi]$
e.	The general term of the resulting series after applying the operation Ω' on the propositional basis ξ (cf. 6.02)	$[\Omega^{0'}x, \Omega^{\nu'}x, \Omega^{\nu+1'}x]$
f.	The general form of an integers (6.03)	$[0, \xi, \xi + 1]$

The general form of any series (a, d) (cf. explanations of 4.1273 and of the formalism introduced up to 6.02) is a variable that must contain a starting point, a law of action and a result: the internal structure of the series has the expression $[x, \xi, \Omega'\xi]$, where "x" represents the given elementary propositions, "ξ" the proposition variable resulting from the application of the operation "Ω'" on "x", which results in the string $[\Omega^{0'}x, \Omega^{\nu'}x, \Omega^{\nu+1'}x]$ (6.02).

The formal analogy between the general term of a series (a,d), the general propositional form (b), the result of the action of an operation (c,e) and the general form of the integer (f) shall be observed. The general form of the Relation is the general form of the operation as a transition from one proposition to another; the relation, the operation, the proposition are united as general forms and represented in a single concept that shows everything that all logical propositions have in common and this is the only logical constant. Here we have, Wittgenstein argues, the essence of the proposition or the essence of the world. (5.47, 5.471, 5.4711)

The operation as a general logical form has as an argument the elementary propositions in a Logical Space and results in a propositional function. The way of defining the operation allows

the successive application of an operation to its results (5.3), which results in "advancing in a series of forms" (5.25) because the operation can become its argument, unlike functions (5.251) and thus avoid the paradoxes of set theory and type theory. If we were to wonder by what internal mechanism such an "alchemy" occurs, the answer would be that it is the negation of the totality of propositional functions (as an argument of elementary propositions) in the operation argument, which still raises problems of interpretation. The idea is that in a given Logical Space, the process of successively applying one or more operations to the respective bases stops, the process has no more signification (*Grigoriu, 2018*)

However, it comes down to defining (intuitively, as a rule of signs) the natural number as the exponent (or index) of a logical operation (6.021), i.e., from the general form $[\Omega^{0'}x, \Omega^{\nu'}x, \Omega^{\nu+1'}x]$ the string is extracted from the exponents of the operation Ω: $0'$, ν', $\nu + 1'$and so on. This was one of the most important aims of *Tractatus*.

"Mathematics is a method of Logic"

The statement "Mathematics is a Method of Logic" (6.234) indicates not only that mathematics is founded on logic, but also that they share a common foundation—i.e., common internal structures that do not contain "statements about" or "assert themselves through sentences", but instead show, manifest, and reveal themselves through a natural symbolism.

This is a logical symbolism that exists beyond logic itself, as it is not grounded and does not obey the very laws that it generates: "... logic is not a field in which *we* express what we wish with the help of signs, but rather one in which the nature of the absolutely necessary signs speaks for itself. If we know the logical syntax of any sign-language, then we have already been given all the propositions of logic." (6.124).

The result is Representationalism, Realism (where structures are discovered), and Intensionalism (where structures pertain to the internal properties of objects).

Mathematics is a method, but it is not reducible to logic, as they have different meanings and occupy distinct domains of meaning.

The representation of general logical forms is preserved in mathematical forms; their common internal structures are given, and they share the same logical form. What differs, however, is meaning—the "outer shell", the manner in which they are materialized in current symbolism (6.031, 6.11, 6.111, 6.1232).

Thus, even if Mathematics and Logic share the same general forms, they do not share the same functions and do not engage in the same general philosophical inquiry.

Conclusions

In the *Tractatus*, meaning is eliminated from logical syntax, just as the concept of identity and the sign of equality are removed from conceptual writing. The universal quantifier over "x" is replaced by the existential quantifier and an additional variable, "y", which does not satisfy the predicate of "x".

For Wittgenstein, identity is intrinsic to the object, and the "=" sign is avoided through alternative notation.

Signification is logical and immanent (*representationalism*), and if it is not unique, it is related

to logical interpretations, uses, or differing conventions (*immanently logical*).

Relation pertains to the internal logical structure of things and is not an analyzable external sensory complex (*as it is in Russell's framework*).

Negation is connected to the deepest structural intimacy of the internal proposition and, together with the symbol of totality, leads to a process that formally exhibits the structure of the propositional sign.

Logic and mathematics are their representations.

Additionally, I note that in the *Tractatus*, it is not stated that there is only one logic of language, but rather that there is only one logic of symbolic language, to which language can or should generally be reduced. When this reduction is not possible, we step into the realm of silence.

Conflict of Interest

The author declares that there is no conflict of interest.

References:

Frege, G. (1948). Sense and reference (transl. by Max Black). *The Philosophical Review*, *57*(3), 209–230.

Frege, G. (1950/1960). *The foundations of arithmetic* (transl. by J. L. Austin). Harper, New York.

Grigoriu, I. (2017a). Tractatus Logico-Philosophicus – internal and external contradictions, and translation issues. *Probleme de Logică*, *20*, 67–92. Bucharest: Romanian Academy Publishing House. (In Rom.)

Grigoriu, I. (2017b). Logic Universe Generator. The general form of a proposition. Bidimensional logic. *Probleme de Logică*, *22*, 151–180. Bucharest: Romanian Academy Publishing House. (In Rom.)

Grigoriu, I. (2017c). *Prolegomena for a philosophy of mathematic*. Bucharest: Eikon Publishing House. (In Rom.)

Grigoriu, I. (2018). Philosophy of logic and logicist failure in the Tractatus Logico-Philosophicus. *Probleme de Logică*, *21*, 67–95. Bucharest: Romanian Academy Publishing House.

Grigoriu, I. (2019). Wittgenstein's philosophy elements of mathematics in the ideal space of the thirties. *Revista de Filosofie*, *66*(5), 615–649. Romanian Academy Publishing House, Bucharest. (In Rom.)

Russel, B., & Whitehead, N. (1925-27/1968). *Principia Mathematica* (1) (2nd ed.). Cambridge University Press.

Wittgenstein, L. (1961). *Tractatus Logico-Philosophicus* (transl. by D.F. Pears and B.F. Mc Guinness). London: Routledge & Kegan Paul.

Wittgenstein, L. (1969). Tractatus Logico-Philosophicus. In *Wittgenstein Schriften I* (pp. 11–83). Frankfurt am Main: Suhrkamp Verlag. (In Ger.)

Wittgenstein, L. (1974). *Tractatus Logico-Philosophicus* (transl. by D.F. Pears & B.F. Mc Guinness). London: Routledge & Kegan Paul.

Rybakov, N. S. [a][15], *Torubarova, T. V.* [b][16], *Yarmolich, N. A.* [c][17], *Tkach, E. N.* [d][18], *Kochneva, L. V.* [e][19]

HUMAN SECURITY IN THE DIGITAL ENVIRONMENT [8]

Abstract: The article deals with the problem of human security in terms of immersion in a digital environment. At the same time, security is considered as protection from internal and external threats. The question is raised about the need to develop an integrated security concept. It is noted that the process of digitalization of the social world is becoming total, new concepts are emerging to describe its conditions. The characteristics of the digital environment and the digital world are given, and the existence of a person in the digital world is described. It is stated that the most important indicator of a person's existence in such a world is his sensuality. The role of impressions in human life and society is increasing dramatically, an industry for the production of impressions and trade in them is developing in the world, which affects the decrease in the stability of society. The article reveals the main directions of transformation of human nature and manipulation in modern conditions. Discussing the ways of forming and strengthening mental immunity, the idea of which is expressed in the scientific literature, the authors, nevertheless, argue that we should be talking about social immunity, a private modification of which is mental immunity. It is noted that in the development of the concept of integral security, which is so necessary for modern Russia, a decisive role belongs to philosophy, which formulates ideological and methodological principles of security.

Keywords: digitalization, digital world, digital environment, mentality, spirit, soul, body, human nature, mental immunity, social immunity, integral security concept.

Introduction

The problem of human security in the information environment is quite general and relevant. After all, the information environment itself is quite new and unusual, which a person has not yet had to deal with in his life, both in terms of its direct manifestation and in the context of long-term consequences. Thinking about its essence, we find that each concept used in the name requires additional research and disclosure. What is security? What is a human being? What does human security mean? If human nature has many faces—from the physic-chemical composition to its mystical self—where and how does the general line of security lie, if it is possible to talk about it at all? What is an environment? What is digital? The concept of "digital environment" is a specific concept formed from the generic concept of "environment" with the addition of a specific difference—digital. However, environments can be diverse, so here you immediately have to specify this concept by immersing it in a specific subject area. Finally, by

[a] Nikolay S. Rybakov, Doctor of Philosophical Sciences, Professor of the Department of Philosophy and Theology, Professor, Pskov State University. Pskov, Russia. ORCID 0000-0003-1007-6001. E-mail: nik-rybakov@yandex.ru

[b] Tatyana V. Torubarova, Doctor of Philosophy, Professor, Department of Philosophy, Kursk State University. Kursk, Russia. ORCID 0000-0001-7319-6428. E-mail: ttorubarova@rambler.ru

[c] Natalya A. Yarmolich, Candidate of Philosophical Sciences, Associate Professor, Department of Philosophy and Theology, Pskov State University. Pskov, Russia. ORCID 0000-0001-7101-1215. E-mail: yarmol92@yandex.ru

[d] Elena N. Tkach, Candidate of Psychological Sciences, Associate Professor, Pacific National University. Khabarovsk, Russia. ORCID 0000-0003-0324-9330. E-mail: pub@eiid.eu

[e] Lyubov V. Kochneva, Ph.D. in Psychological Sciences, Associate Professor, Department of Sociology, Psychology and Social Management, National Research University "Moscow Aviation Institute". Moscow, Russia. ORCID 0000-0002-7439-7798. E-mail: shafrans@mail.ru

combining the four concepts into a single whole, we get a new semantic thematization of the problem that requires a thorough discussion.

Conversations about digitalization are taking place everywhere—from home conversations to the media and scientific forums. There are legends about the success of neural networks in general. Neural networks cover a wide variety of fields of activity: pattern recognition, noisy data processing, image augmentation, associative search, classification, optimization, prediction, diagnostics, signal processing, abstraction, process management, data segmentation, information compression, complex mappings, modeling of complex processes, machine vision, speech recognition. Many people have probably heard that neural networks are already writing term papers and theses, creating artistic and scientific texts, and in the style of that other writer, thinker. The networks are used by priests to create sermon texts, which they then deliver to parishioners. And believers really like it. In a certain way, configured networks can participate in ideological sabotage, introducing a wide variety of values into people's minds—from classical to the most radical and unconventional. Therefore, the issue of human security in modern conditions is quite relevant.

Materials and Methods

In the process of working on the problem of digitalization, various publications were analyzed and various methods were used. Among them are the textual analysis of primary sources and modern articles, the comparative method, methods of system analysis and analogy, logical and historical methods, the combination of abstract and concrete approaches. The main attention is paid to the logical side of the problem in comparison with the historical one.

Results

So, what is security? Already at the level of everyday ideas, it is associated with protection from internal and external threats. Security is security, and the more intense the threat, the more reliable the security should be. Security is functionally implemented in the protection process. Who is the subject of protection, in other words, who protects? The subject of protection can be an individual, a group, a collective, and the state and society can act as a limit. What or who becomes the object of protection, what and whom have to be protected? First of all, it is necessary to protect the life, health, interests, ideals, freedoms, and values of individuals. Quite a lot of objects have to be protected in society, and their list turns out to be very mobile. The sources and grounds of its existence and functioning, resources: natural, economic, food, social, political, national, spiritual, educational, demographic and others are subject to protection in society. Since the subjects of public relations are people, the security system should be built with special care in a strategic plan involving both anthropological and social elements.

Security is achieved through a set of actions aimed at neutralizing various threats. Therefore, a safety measure is a measure of the system's immunity to external and internal influences. These impacts can be of two directions: constructive and destructive. Constructive ones are aimed at increasing the stability of the system, destructive ones are aimed at destroying the stable existence of the system, at dumping it into a state of chaos. Security is the provision of a stable (stable and holistic) existence and functioning of the system, therefore, constructive influences work to increase security.

The primary line of protection, and therefore of security, runs along the border of the state and is aimed at preserving its territorial integrity. But this is not enough for integral security. In Russia, the doctrines of economic, food, demographic, educational, scientific and other types of security are being worked out, which is extremely important for preserving the integrity and self-sufficiency of the country. In the modern world, the problem of security is shifting into the conceptual and semantic sphere: from the protection of material resources (economic, food, energy, fuel, human, etc.) to the protection of knowledge, scientific information, fundamental spiritual and semantic components that preserve the deep memory of the people, nation, ethnos. Currently, information wars are giving way to concessional wars aimed at destroying the psychology, consciousness, and soul of the people – these deep carriers of the identity of the subjects of the historical process. The French psychologist G. Lebon argued that the people "can lose a lot, undergo all kinds of disasters and still be able to rise. But everything is lost to them, and he will never rise again if he has lost his soul." (*Lebon, 1995, p. 47*).

Digitalization, the Digital Environment and the Digital World

Currently, there is a lot of writing about digitalization. At the same time, dozens and even hundreds of concepts with the adjective "digital" and with the noun "digitalization" are used: the digital era, the digital revolution, digital money, digital culture, digital education, digital anthropology, digital humanities, etc. They are used in everyday life, in political rhetoric, and "participate in state protection strategies" (*Sokolov, 2020, p. 12*). This topic is fashionable, so, writes one of the authors, in these conditions, the appearance of all kinds of nonsense and absurdities cannot be avoided. He reasonably writes that everything claimed "in the rhetorical arsenal of digitalization/informatization is fiction... These are empty words, fascinating and tempting irresponsibility…" (*Sokolov, 2020, p. 27*). But he also emphasizes that to regard "this simply as stupidity, fashion, madness… would be a mistake, because… there is "something to talk about"… a number of problems arise here that are insoluble… within their "digital-information discursivity", but are located beyond it" (*Sokolov, 2020, p. 28*). The problem is that the term "digitalization" is used in two senses—narrow and broad. In a narrow sense, this is a transition from an analog form of information transmission to a digital one, in a broad sense it "covers production, business, science, the social sphere and the ordinary life of citizens; its results are used not only by specialists, but also by ordinary citizens." (*Khalin & Chernova, 2018, p. 47*)

All this indicates that a new digital environment is being formed in the life of modern man and society, into which all spheres of life are gradually immersed—from industrial to intimate. But it is very difficult to find a generally accepted concept of the digital environment in the scientific literature. Some sources indicate that the digital environment includes all the variety of information technologies and cyberspace and has an infrastructure (tele-communication and Internet lines, computing complexes of various dimensions, computing control embedded blocks), structure (network software protocols, programs and software platforms, software interfaces (interfaces of websites, blogs, portals)) and ultrastructure (public network resources such as websites, blogs, portals, social networks, protected resources of government and corporate affiliation, public resources with paid content). They talk about such important trends in the digital environment as a sharp increase in the volume of information (information

explosion) and the formation of the Internet of Things—a variety of technological, industrial, infrastructural devices, devices, devices with control units, information transmission and management connected to the Internet.

The Internet is metaphorically called the world Wide Web, containing huge amounts of information, the digital environment is a habitat, a new reality is emerging that has not yet been realized. To understand the digital environment, a biological metaphor is sometimes used—the information component of artificial biogenocenosis, which helps to assimilate energy and matter in this biogenocenosis. But information, unlike matter and energy, is not consumed, but multiplies, and in a digital environment there may be both true information values and false ones, which significantly confuses the understanding of life processes in such an environment.

According to some researchers, the digital environment should be based on the scientific justification of those functions of society as a system that support its stable existence and development. However, in modern conditions, the creation of a digital environment takes place under the full control of a small part of society, through scientific circles that are associated with corporations aimed at establishing world domination. This is expressed in the desire to redistribute the management of the flows of not only matter and energy, but also information in the interests of this minority. It is not by chance that the expression arose: "Who owns information owns the world." Meanwhile, the digital environment should stimulate the development of society as a whole, and not exclusively the owners of resources, including information.

Along with the concept of the digital environment, the concept of the digital world is used, which takes into itself in a generalized form everything that a person encounters, transforming modern existence on an information basis. The concept of the digital world carries the greatest ideological load, because it is through understanding the digital world, its features, elements, dynamics that a person's life position is formed, value attitudes, beliefs are formed, from which his actions grow and his fate develops.

A Person in a Digital Environment

Digitalization is in full swing. It is associated with the prospects of economic development, the work of finance, administrative management, and the country's defense capability. It intensely invades the fields of education and healthcare. Nowadays, without it, the existence of a person integrated into information flows becomes impossible. But in addition to the positive impact on human life, it also contains negative elements, and some researchers even talk about an anthropological catastrophe. Thus, digitalization brings not only benefits, but also leads to the emergence of such negative phenomena as the degradation of natural intelligence, the spread of clip thinking, the growth of intellectual and mental dependence of people on computer devices, blurring the boundaries between the real and virtual world, and a decrease in the quality of education.

For example, today there is no need to store various information in your memory (phone numbers, addresses, dates of family holidays, notebooks have lost their relevance: all this can be entered into a notebook in your phone. At the same time, many researchers believe, not without reason, that this will lead to an atrophy of the intellectual abilities of the majority of society. They are already talking about the emergence of a disease called "digital dementia", as people

gradually lose the ability to reason. In particular, students and schoolchildren, when accessing the Internet for almost any question, receive ready-made answers contained on different sites, as a result of which the thinking process is gradually replaced by the consumption of ready-made information.

The first generation has already grown up, for whom there are no problems with mastering digital technology. However, there are new devices with higher performance and speed of transmission of information flows. Therefore, the acquired knowledge of this generation requires constant updating of information and new ways of obtaining it, but again without much thought. As a result, a "clip-on way of thinking" develops, which is expressed in the "inability of a person to hold a thought".

The conditions of human existence are radically changing, leading to the breakdown of his lifestyle. One of the problems is related to a person's identity. Identity is not a psychological category, as it is widely represented in the literature, but a deeply metaphysical one, expressing his self (I am myself). The Russian philosopher B. P. Vysheslavtsev calls it mystical: "The self is the last and highest… mystical stage in the human being. For science, for rational thinking, it is unattainable and unprovable. The self is metaphysical and metapsychic. Only Revelation and mystical intuition point to this ultimate depth. In practical life, in the knowledge of the world, even in the creative work of culture, it can remain completely unnoticed." (*Vysheslavtsev, 1994, p. 285*) However, the digitalization of memory as a kind of storage of the self allows it to be adjusted and even reformatted. Human actions in networks leave digital traces accessible to external authorities that control information flows, therefore, to external influences. The objectified memory in information networks becomes the property of other people who can use it without your knowledge and manipulate your identity. As a result, a person ceases to be the master of information about himself, losing the main essential core of his being—the self.

Being in the Digital World

In the context of digitalization, information relations between people are symbolic, they turn out to be difficult to perceive sensually. Therefore, the strengthening of the role of the sphere of sensuality becomes a kind of compensation for supersensible symbolic and semantic relations. The law of increasing needs in the classical capitalist world is being replaced by the pursuit of emotions, impressions, and the law of increasing emotions is being formed, according to which, in order to keep a person in the right emotional tone, he constantly needs the addition of new emotions, which should become stronger and stronger. The closest indicator of a person's existence is his sensuality, his psycho-emotional states. Compare the Cartesian one: I think, therefore I exist with the current one: I feel, therefore I exist. The meaning of existence is shifting into the realm of sensuality. Cinematography, using the latest computer technologies, allows you to accelerate sensory-imaginative perception to incredible limits, to produce more and more new emotions: from an advertisement on Russian TV for another film "Discovering new experiences". Their role in human and social life is dramatically increasing. There is an outburst of emotional charges, emotional excitement sometimes reaches the point of losing control over them. An industry is developing in the world aimed at producing impressions, trading them, and people are chasing new impressions, new thrills, ready to pay a lot of money for them. Due to the sharp increase in emotions in the life of society, there is a danger of losing

control over them on a large scale, and uncontrolled extreme emotional arousal turns into one of the destructive factors of stable social existence. At one time, Feuerbach tried to build an understanding of man and society on the basis of sensuality for which he was criticized by Marx.

What is the problem here? In the processes of digitalization, there is a desire to completely reprogram the development of man and humanity, to subordinate it to the most powerful, influential elites, as K. Schwab, the ideologist of the World Economic Forum, openly writes. In the new world, according to his statement, people will have no property, but they will be happy. In the process of reformatting the world with the help of Internet technologies, it is assumed that the spread and implantation of the basest instincts and human traits, manipulation of consciousness, etc. The founder and first president of the World Health Organization, D. B. Chisholm, writes bluntly: "To come to a world government (i.e., to establish domination over the world), it is necessary to expel from people's consciousness their individuality, attachment to family traditions, national patriotism and religious dogmas… The destruction of the concepts of truth and falsehood, which are the basis of a child's upbringing, the replacement of faith in the experience of elders with rational thinking—these are belated goals… needed to change human behavior." (*Ilnitsky, 2021, p. 29*)

All this means the emergence of a new type of wars, with the help of which the world is being reformatted. They are called in different ways: informational, cognitive, conceptual, mental, evolutionary, etc. Apparently, these wars should be classified, and species differences should be identified among them, since each such name carries slightly different signs. And here, as it turns out, the most vulnerable link in human nature, through which one can most effectively influence his nature, is precisely the sensory sphere, through which the influence on the ways of human perception of the world is performed.

The most dangerous consequence of digitalization at the level of the unfolding of such wars is the emergence of the possibility of purposeful (artificial) control of human evolution through the imposition and dissemination of unnatural values and needs through the Internet, propaganda and motivation of base instincts and primitivization, substitution of cultural values, manipulation of consciousness, widespread lies, disinformation, hypocrisy, the entrenchment of double standards, etc. The danger is that it is impossible to reverse the course of evolution by intervening in it, and it is even more difficult to foresee not only the long-term, but also the immediate consequences. Moreover, they will not appear immediately, but after one or two generations, when it will be simply impossible to do anything. The main weapon in this type of war is the Worldwide Network. Therefore, whoever owns it and fills it with content has a strategic advantage. Unfortunately, it should be noted that in this case the advantage is not ours and our ability to repel evolutionary attacks is still extremely limited.

New wars and security. In a classic war, to win, you need to defeat the enemy and capture his territory. Now it's not necessary. It is possible to destroy the state, destroy the country by changing the identity, worldview, goals, values and priorities of society. The evolutionary and mental warfare associated with it are aimed at changing the worldview. The worldview includes knowledge, values, beliefs, will, and actions. In this regard, irreversible changes in the worldview can be pdrformed for each of these elements, as well as comprehensively—for all at the same time.

The transformation of knowledge leads to a radical change in the education system. And, therefore, a change in the concentration and ways of broadcasting social experience from generation to generation. The transformation of values means the introduction of new, alternative to traditional values into people's consciousness. The transformation of beliefs is their reformatting. Older people remember that a lot of attention was paid to the formation of communist beliefs in the USSR. The problem was particularly discussed: is it possible to change one's beliefs, and if so, under what conditions. In general, the logical form of persuasion can be expressed as follows: "Someone S accepts at a given time t1 event (phenomenon) P." The transformation of a belief for the same subject S, but at a different point in time t2, should give a different result: subject S does not accept the event P. The transformation of the will is found primarily in its neutralization, a change in the direction of action: if a certain subject, e.g., a politician, was determined to take an effective and effective action (step), then after influencing him under changed circumstances, he renounces his action and takes steps acceptable to his political opponents. How often do the highest circles of power lack political will! The transformation of actions is, first of all, the legitimization of permissiveness. As a result, we get a person without internal restraints, unbridled, mentally unbalanced, etc. Moreover, these transformations can be performed for many years almost at the molecular genetic level.

In general, information and psycho-emotional components are distinguished in such wars.

The information component is the reformulation of the information field, the field of knowledge, facts and information. Everything is subject to deformation—from news to various data, from study programs in higher education institutions and schools to television programs and available archival data. A special role here is assigned to the factual basis of information, and in the present era the understanding of the fact is radically changing. If in the broad everyday consciousness, not to mention the consciousness of a scientist, a politician, a fact was associated with the reliability, the truth of the representation of events, hence the methodological requirement of relying on facts arises, then now they are talking about facts-simulacra, fakes, the phenomenon of "post-truth", a special fact-checking procedure—fact checking. This indicates a person's distrust of the empirical basis of the information received. Epistemologically, this circumstance shows that the ways and means of comprehending and comprehending the world by man have become much more complicated.

Here are some testimonies. "An entire industry has developed on the Internet for the production of fake news and the dissemination of disinformation, while the social networks in which this happens are not able to distinguish truth from fake, so that facts and simulacra (pseudo-facts) here turn out to be equal to each other." (*Rybakov, 2017, p. 122*)

"Fakes and related ideas about post-truth are topics that cannot be dispensed with when trying to comprehend modern public communication, media space, and political technologies… However, the creation technologies and channels for broadcasting fake information are expanding and branching, the problem is becoming more and more profound and far from being resolved." (*Tulchinsky, 2021, p. 5*)

"The phenomenon of "post-truth" in modern political communications is increasingly the subject of analysis in foreign and domestic scientific discourse, but in semantic terms, the concepts of "post-truth", "post-truth politics" remain very vague… At the same time, all participants in the discussion on the political risks of "post-truth politics" or "post-factual"

politics (post-factual politics), which replaces facts with "fake news" ('fakes'), somehow associate such phenomena with a change in the mode of production, dissemination and influence of political information in the public sphere." (*Zakonchinsky, 2018, p. 6*).

The psycho-emotional component is based on the manipulation of consciousness, moods and emotions, when an individual, groups of people and society as a whole are installed the desired moods, assessments, opinions about something and about someone, and all this is accepted by people unconsciously, without understanding the essence of what is happening. At the same time, the effectiveness of technologies for manipulating human consciousness is extremely high, reaching, according to some sources, 70%, and under the influence of this influence, people make decisions, sincerely believing that they make their choice exclusively themselves, no one imposes it on them. The media tend to enhance this effect of self-deception by emphasizing that the choice is allegedly made by the person himself of his free will.

The imposition of alien concepts, meanings and values on modern Russia reaches gigantic proportions, although we very poorly understand this, and again and again we build illusions that it is enough to once again redraw a history textbook for schools or introduce a compulsory course for university students—and everything will resolve itself.

Directions of Manipulation and Their Smoothing

Knowing the main directions and ways of human transformation in informational and psycho-emotional actions, it is possible to predict the methodology of smoothing and mitigating such impacts. Of course, there can be quite a few specific methods. But they are recognized by the prevailing situations. Therefore, it is important to identify precisely the strategic positions that allow us to classify the directions of impacts. We believe that in the case of human transformations, such nodal positions can be, in accordance with the Christian doctrine of man, body, soul and spirit.

Even in everyday life, a person is very strongly exposed to informational, psycho-emotional and other influences.

For example, take the human body. According to Christian anthropology, the body represents nature in man. It is the most complex and numerous in comparison with the spirit and soul, in the body and through the body, all the diversity of the world is represented in man. Body transformations, starting with harmless bodybuilding, which is now turning into bodybuilding, plastic surgery, injections, beauty salons, which arise everywhere and which, as it were, are designed to reduce to some extent the degree of concern and anxiety of people about their unsatisfactory and imperfect appearance, and ending with sex reassignment operations, are far away This is not a complete list of those multifaceted physical transformations that are becoming widespread in their scope and the consequences of which are still difficult to predict. But the transformations of the body cannot but affect human nature and his worldview. It is good if these transformations are aimed at improving human nature. However, if the physical changes of the body turn out to be mutations, then what kind of spiritual perfection, what kind of progressive change in a person's worldview can we talk about?

Note that the question of the human body is not so simple and cannot be reduced solely to the biological organization of a person. However, even in this area, the problems of implementing biotechnologies in various areas of human life and society are widely discussed.

For example, these are the use of biotechnologies for military and agricultural purposes, the production of genetically modified cells and tissues, etc. (*Budanov, 2022, p. 74*). K. Marx at one time spoke about the "inorganic body" of man. The so-called "digital body" is discussed in modern literature. All these and other variations in the understanding of the body indicate an extremely complex problem that is very difficult to master by the person himself.

The soul is another important component of human nature, which also has a multi–component structure. It distinguishes a small (spiritual) mind, desire and feeling. Each of these elements is also affected: the small mind is transformed, e.g., through the education system, which is now becoming one of the most noticeable factors of damage to the soul; desire—through the formation of attraction and lust, through the arousal of the desire, for example, to become a millionaire, make a career, achieve success; feeling—through the incitement of passions, emotions and affects, Trading emotions and impressions, as mentioned above, becomes a successful field of services and business.

The directions of transformation of parts of the soul can be realized both spontaneously, independently of each other, and purposefully, systematically. How deep and bottomless the spiritual life is can be judged by the works of the holy Martyr Peter of Damascus (the 12th century), who counted 298 different passions and 228 virtues (*St. Peter of Damascus, 2001, pp. 200–206*). Therefore, in the presence of developed psychotechnics, it is not so difficult to transform a person's mental life, distort and damage it. This is what numerous psychological trainings and training centers are doing, scattered all over the world and destroying the human psyche, and with it the soul. It is possible that in the near future the world will learn about very sophisticated ways of soul decomposition. But it is much more difficult to fix it.

The spirit, the third element of human nature, is associated with freedom, boundlessness, mobility, activity, higher intelligence, eternity, immortality. It consists of mind (spiritual), will and power, forming a unity. The spirit is broader than the intellect (mind), it is not the will taken by itself, and the will is not the spirit. The spirit is more universal than the will. One can speak about the spirit only with regard to its trinity. Outside of the spirit, its individual parts lose their abilities, and taken separately, they destroy the spirit. The mind plays a decisive role in the activity of the spirit. Will follows thought, action follows will. The will directs action, and on its basis a person makes a decision to act or refuse to act. The execution of an action depends on the applied force, without it neither the mind nor the will can manifest and be realized. The integrity of the spirit lies in the synergy of the action of its parts, without which the spirit is deformed and even disintegrates.

The directions of transformation and mutation of the spirit are dictated by its composition. This is, first of all, depriving the spirit of its intellectual (reasonable) origin, creating conditions for its clouding. A mind that neglects will and power loses the ability to undertake and implement anything. The will that does not follow the mind, that precedes it, is an autonomous will that has lost its rationality. If it suppresses reason and power, it turns into voluntarism, ignoring objective circumstances and factors. There are numerous technologies for neutralizing the will. The force that does not follow the mind ("there is power—there is no need for mind") and the will becomes unreasonable, which also turns out not only unpleasant, but often tragic consequences for man and society, reformatting and destruction of the direction of force action, its dispersion, minimization of concentration. It is no coincidence that in ensuring the safety of

human life and society in the second half of the 20th century. of particular importance are the so-called conceptual (semantic) wars, i.e., wars for the "last, deep, metaphysical essence of being", for changing the traditional meanings that root a person in his being.

Conclusions

The body, soul and spirit, which form the trinity of man, are heterogeneous principles. In the history of philosophy and religion, the idea of a "whole man" was constantly floating, which received very different interpretations. In order to unite heterogeneous principles, a body uniting them is needed. Such an organ, according to the teachings of Christian anthropology, is the heart, which itself must be at the same time a spiritual, mental and bodily organ, or, in other words, the center of the spirit, soul and body. The teaching of the heart has also played a very prominent role in the religions and philosophies of different peoples. When modern philosophers excitedly discuss various problems of informatization and digitalization, they say almost nothing about it. Although they state: "The main challenge of the digital environment for a person is a challenge to his integrity. Most of the important characteristics of a person are based on the representation of a person as an integral being." (*Trufanova, 2021, pp. 371*) However, if there are threats to integrity, then the main blow is directed precisely at its center.

Fully agreeing with such a statement, we consider it our duty to note that although in the history of mankind the idea of a whole/integral person once appeared, there has never been such a person in the real world. Although various thinkers have tried to create a theoretical construct of a whole person, nevertheless, it is still extremely difficult to find a good description of what a whole person is that most authors could accept. Even the Christian concept based on the synergy of spirit, soul and body is not complete and indisputable when compared with the Marxist understanding of man as a generic being. Recall that it includes the self, the body and the human world. Moreover, the latter element forms the so-called "inorganic body" or society. Therefore, sociality should obviously not be taken out of the brackets of human nature. This, however, is understood by almost all researchers, but the way this structure is embedded in the authors' reasoning leaves much to be desired.

Informatization, digitalization and all the totalities of the world of human existence that are associated with these processes are performed in a society that does not represent an external environment in relation to a person, not some annoying appendage from which one can abstract, but that essential substance that changes before and deeper than everything that happens in this transformational world with a man. The dynamism of human nature is inseparable from the dynamism of social relations, which are being transformed just as radically. Suffice it to say that in the case of a classical bourgeois society, a thing becomes an intermediary in relations between people, like a manufactured product, whereas in the modern world information turns out to be an intermediary in relations between people. If we compare the nature of a thing as a commodity, taking into account all its social adventures, with the nature of information as an intermediary, then its social adventures will turn out to be much steeper many times.

Actually, many of these adventures are revealed and depicted quite impressively by various authors writing on the topics of digitalization. However, they lack a sense of sociality to portray the ongoing processes in their universality. However, apparently, the conditions have not yet

matured for this: there are plenty of databases, but they have not yet appeared in a new light. Human transformations without transformation of sociality will be portrayed partially, one-sidedly. Only on this path, apparently, the problem of security will appear in its integrality and comprehensiveness.

Modern Russia urgently needs an integrated security strategy, in the context of which it is only possible to talk about its socio-political and economic well-being. However, if we understand security as security, then within the system itself, the security of which is in question, a mechanism must be formed that provides it with the ability to resist external influences, to resist them, i.e., to defend itself.

It is known from biology that the condition for maintaining the independence of a living organism is its rejection of foreign information. Without such an ability, the body dies, in the worst case, ceases to exist independently. In biology, the principle of heterophobia is formulated—the fear of heterogeneity—which characterizes the individuality of an organism, indicates its independence. Living organisms, including the human body, have an immune system that rejects everything foreign to this organism.

Humanity on planet Earth exists in the form of a huge variety of countries, states, and peoples, which in the most general sense are social organisms. Among them there are both extremely primitive societies and complexly organized and differentiated societies. Nevertheless, they all function as independent indivisible entities, regardless of their complexity.

A social organism is a system of a much higher order than a living organism, with a more flexible system of self-defense and self-preservation. In such a system, the measure of its openness must also be respected, and there must be a limit to external borrowing and imitation. In other words, in such an organism, social immunity must be formed and be the subject of constant care. Only in this case can we hope to preserve the culture, identity, and identity of such a social organism. Only in this case can we hope to take a worthy place in the general system of world social structures and adequately respond, as many scientists like to repeat, to the challenges that the constantly changing world throws at us. A person and society should have a developed immune system capable of rejecting foreign influences and interventions.

If once, after the lifting of the Iron Curtain, Russia began to function as an open society, then we forgot that the social organism should have a limit to openness. When it is destroyed, it is no longer possible to preserve culture, identity, or identity. Security as security is reliability, confidence, certainty, perspective, self–sufficiency of existence. Unfortunately, the Russian media cultivate the psychology and consciousness of alarmism and catastrophism day after day, which makes them "disruptive" to various threats, reduces the degree of protection, generates a mood of indifference, value neutrality both in relation to the negative and in relation to the positive. And this does not contribute to the preservation of Russia's security at the very core of its existence.

The issue of mental immunity is raised and discussed in the scientific literature. "Mental immunity is the ability of a separate group of persons or an individual to ensure their socio-cultural (mental) identity, integrity (habits, lifestyle, communication, etc.), and immunity to externally imposed social rules and attitudes. As a general rule, it is ensured by the joint efforts of citizens, society, the state, and in cases of imbalance of the system—by separate self-

governing groups (according to territorial, ethnic and other characteristics)—independently." (*Mokhov, 2023, p. 21*)

Agreeing with the idea expressed in general, we note, however, that in fact we are not talking here about mental, but about social immunity, a special case of which is mental immunity. This is especially clear in the light of the trimeria of human nature—spirit, soul and body. Understanding the problems of social immunity and developing on this basis a methodology for its formation and development in various diverse forms is a complex task of many sciences, the main role among which is assigned to philosophy, which is designed to develop the ideological basis of the integral concept of Russian security, one of the modifications of which is digital security.

Conflict of Interest

The authors declare that there is no conflict of interest.

References:

Budanov, V. G. (Ed.). (2022). *Anthropomericity as a challenge and response of modernity: A collective monograph*. Kursk: University Book. (In Russ.)

Ilnitsky, A. M. (2021). The mental war of Russia. *Military Thought. A Monthly Military Theoretical Journal*, *8*, 19–33. (In Russ.)

Khalin, V. G., & Chernova, G. V. (2018). Digitalization and its impact on the Russian economy and society: events, challenges, threats and risks. *Management Consulting*, 10, 46–63. (In Russ.)

Lebon, G. (1995). *Psychology of peoples and masses*. St. Petersburg: Layout. (In Russ.)

Mokhov, A. A. (2023). Mental security and mental immunity: organizational and legal aspect. *Modern Law*, *2*, 19–23. https://doi.org/10.25799/NI.2023.22.54.003. (In Russ.)

Rybakov, N. S. (2017). Fact as a simulacrum. *Philosophy in the Modern World: A Collection of Scientific Reports of the International Scientific and Practical Conference Dedicated to the 25th Anniversary of the Seminar "The Problem of Knowledge Development" and the 70th Anniversary of the Professor Alexander Fedorovich Kudryashov*, *Part 1*, 113–122. (In Russ.)

Sokolov, E. G. (2020). Digital epoch. Preliminary markup. To install the problem. *Philosophical Analytics of the Digital Age: Collection of Scientific Works*, 7–37. St. Petersburg: Publishing House of St. Petersburg University. (In Russ.)

St. Peter of Damascus. (2001). *The creations*. Moscow: Publishing House of the Moscow Monastery of the Holy Trinity Sergius Lavra. (In Russ.)

Trufanova, E. O. (2021). Human in the digital world: "Distributed" and integral. *Perm University Herald "Philosophy. Psychology. Sociology"*, *3*, 370–375. https://doi.org/10.17072/2078-7898/2021-3-370-375. (In Russ.)

Tulchinsky, G. L. (2021). Fakes: communication, meaning, reflection. In V. Zolyan, N. A. Probst, J. R. Sladkevich, G. L. Tulchinsky, *Collective monograph* (pp. 7–15). St. Petersburg: Aleteya. (In Russ.)

Vysheslavtsev, B. P. (1994). What am I like?. In B.P. Vysheslavtsev, *Ethics of the transformed Eros* (pp. 279–291). Moscow: Republic. (In Russ.)

Zakonchinsky, K. F. (2018). "Post-truth" as an epistemological and communicative aporia. In D. A. Popova (Ed.), *"Politics of post-truth" and populism* (pp. 6–22). St. Petersburg: Scythia-Print. (In Russ.)

Kolyada, A. A. [a][20]

FEATURES OF APPLYING THE CUSTOMER SATISFACTION INDEX (CSI) IN BUSINESS MODELLING, STRATEGIC PLANNING, AND STRATEGIC MANAGEMENT [9]

Abstract: Customer Satisfaction Index (CSI) is one of the most powerful tools for measuring customer satisfaction. The relevance of the study aimed at enhancing the effectiveness of this instrument is beyond question. The scientific novelty of the study lies in the discussion of the specific features of developing and applying the CSI in business modelling, strategic planning, and strategic management. The study's object is the phenomenon of monitoring and managing customer loyalty within an organisation, along with the associated strategic issues. The study's subject is the development and application of the CSI in strategic operations. The study is based on managerial, consulting, and educational projects of the EMAS Business School, as well as on academic articles by other authors. The study explores methodological aspects of the development and application of the CSI, its areas of use, and the limitations of its application in business modelling, strategic planning, and strategic management. The findings highlight the importance of strictly adhering to methodological requirements in the development and implementation of this tool, as well as the value of utilising its potential not only for measuring customer satisfaction but also across other strategic domains.

Keywords: customer satisfaction, Customer Satisfaction Index, CSI, NPS, price satisfaction, customer satisfaction management, brand management, USP, strategic management, business modelling, strategic planning, price competitiveness, business model innovation.

Abbreviations:

CSI is Customer Satisfaction Index,

EMAS is Eurasian School of Management and Administration,

NPS is Net Promoter Score,

USP is Unique Selling Proposition.

Introduction

The economic performance of an organisation operating in a competitive market largely depends on customer satisfaction with its activities—namely, the goods and services it produces. In cases where the nature of the organisation's activity involves repeat purchases by the customer, this satisfaction becomes a critical success factor. Under such conditions, tools that enable regular measurement of customer satisfaction—and the subsequent adoption of strategic decisions to improve it—become essential components of the management toolkit used by effective senior executives.

One such tool for measuring customer satisfaction is the CSI, which represents a more advanced version of the NPS, i.e., an index of customer loyalty (*Reichheld, 2003*). Although, methodologically, CSI is more complex to apply in practice (requiring considerable analytical work) (*Lavrova, 2024, p. 190*) than NPS, it is a more informative instrument and brings

[a] Andrey A. Kolyada, Nizhny Novgorod, Doctor of Business Administration, Rector, Eurasian Management and Administration School (EMAS Business School), Applicant at National Research Lobachevsky State University. Nizhny Novgorod, Russia. ORCID 0009-0005-9725-9370. E-mail: kolyada@emasrussia.ru

substantial practical value. It is one of the key tools in strategic management and business modelling. At the very least, this tool underpins quality management within an organisation and the development (*Kolyada, 2023, pp. 184–220*) of a USP (*Kolyada, 2023, pp. 371–383*), brand management (*Kolyada, 2023, pp. 221–233*), and serves as a vital component in sales forecasting systems.

The application of CSI in strategic marketing enables the management of brand-related advertising campaigns on an analytical basis (this refers to the marketing aspect of brand management, which is narrower in scope than strategic management). The high relevance of this tool underscores the importance of research—such as the findings presented in this article—aimed at supporting methodological development and expanding the range of CSI applications.

Accordingly, the object of this study is the phenomenon of customer loyalty monitoring and management. The subject of the research is the development and application of CSI as one of the most widely used tools for measuring customer satisfaction. Special attention is devoted to discussing the tool's areas of application and its associated limitations. The scientific novelty lies in the formulation of methodological recommendations for the development and implementation of CSI, the identification of its areas of application and related constraints, and the justification for the impossibility of assessing price satisfaction using the CSI.

The scientific novelty of the study lies in the discussion of the specific features of developing and applying the CSI in business modelling, strategic planning, and strategic management.

The study's object is the phenomenon of monitoring and managing customer loyalty within an organisation, along with the associated strategic issues.

The study's subject is the development and application of the CSI in strategic operations.

The study aims to analyse the practices of developing and applying the CSI across various industries.

Based on this aim, the following study objectives have been formulated:

- examine the methodological aspects of CSI development;
- describe the areas of CSI application in strategic management and business modelling;
- substantiate the limitations of CSI application.

Methods

The study was conducted using methods of observation, comparison, and analysis. The empirical base comprised 297 projects in the fields of business modelling and strategic planning. These projects were performed under the academic supervision of the author by participants of the Executive MBA and DBA programmes at the Eurasian School of Management and Administration (EMAS Business School) between January 1, 2021, and December 31, 2024. In addition, scholarly publications by Russian and international authors were used.

In the course of the projects, participants, following the specified methodology (*Kolyada & Plekhova, 2023*), developed a digital version of the business model and strategy of an organisation, and also designed a Customer Satisfaction Index (CSI) for a given product group in a selected market. The projects were conducted for real organisations operating in various sectors of the economy (goods and services), using actual products and market data. They were

performed in both Russian and English for organisations based in Russia, Belarus, Kazakhstan, and further abroad.

During the implementation of the projects, participants discussed the challenges associated with the creation and application of the CSI, its areas of use, and the limitations of the tool. In this context, the participants were senior and mid-level managers of the organisations on whose basis the projects were implemented.

The study was conducted within the framework of developing the Russian academic school of business modelling, strategic planning, and strategic management, perrformed by the research institute "Eurasian School of Management and Administration" (EMAS Business School).

Results

Methodological Specifics of CSI Development

From a methodological perspective, the development of the CSI is a complex process comprising several stages. At each of these stages, the developer encounters a number of challenges, and the validity of the final index largely depends on how competently these are overcome. The development process involves the following key steps:

1. Identification of the Target Cluster (*Kolyada, 2023, p. 42*), Target Segment (*Tretyakov et al., 2005, p. 5*), and, if necessary, a specific customer group within the target segment whose satisfaction will be measured (hereinafter referred to as the "customer group under assessment").

2. Qualitative Research to Identify CSI Characteristics—Conducting a series of focus groups or in-depth interviews with representatives of the customer group under assessment. These studies aim to identify product features and related organisational activities evaluated by customers during the acquisition, use, and disposal of the product, which collectively determine customer satisfaction.

3. Selection of Index Ideology.

The CSI may take the form of a syncretic model, which is the most common. In this model, a unified index structure combines various aspects of the customer experience: satisfaction with the product itself, satisfaction with organisational business processes encountered during purchase, usage, and disposal, and satisfaction with personnel.

Despite its prevalence, this model is not particularly effective from the standpoint of strategic management and business modelling. The issue lies in the conflation of characteristics from different types of consumer experience (e.g., product usage versus purchasing experience), which undermines the comparability and relative significance of these characteristics.

A more effective approach is the discrete model, previously proposed by the author of this article (*Kolyada, 2023, pp. 184–220*). Here, the index is divided into sub-indices, each reflecting a homogenous area of consumer experience. Recommended sub-indices include:

- Product CSI (in the narrow sense)—characteristics related to direct product usage experience;
- Process CSI—characteristics reflecting experience with the organisation's business processes during acquisition, use, and disposal;
- Personnel CSI—characteristics related to interaction with the organisation's staff.

The final CSI may be calculated as the sum of these sub-indices or via a weighted formula, assigning individual weights to each sub-index, multiplying them accordingly, and summing the results.

4. Quantitative Research to Determine the Significance (Weights) of Characteristics—Conducting a survey among a representative sample of the customer group under assessment to determine the perceived importance (weights) of the identified characteristics. Sampling and survey procedures must strictly comply with sociological research standards to ensure data validity.

As the above stages demonstrate, the primary challenges faced by a CSI developer lie in the rigorous adherence to methodological requirements at each step and the selection of an appropriate index ideology. These methodological standards, established by marketing and sociological science, govern both the execution and validity of the outcomes. The choice of ideology depends on the developer's judgement regarding the relative merits of syncretic versus discrete models.

Thus, CSI development involves a broad range of interrelated issues. Deviations from the proper sequence or logic of the process may call into question the index's overall validity and render it unsuitable for assessing customer satisfaction.

For instance, mistakes at Stage 1 can make the index fundamentally unusable.

Errors in Stage 2 (a common one being the developer "inventing" characteristics without research) can compromise the adequacy and completeness of the index in capturing the full phenomenon of customer satisfaction.

A poorly chosen ideology at Stage 3, one that does not support effective satisfaction-based management, can lead to the undervaluation of critical information.

Finally, mistakes at Stage 4—such as incorrect weightings—can distort the interpretation of satisfaction levels, as the weighted values directly affect the final index score.

Methodological Specifics of Data Collection and Management of the CSI

The regular collection of data for calculating the CSI also requires adherence to a number of stages:

1. Quantitative research (measurements) to obtain data for the index. This involves conducting a survey among a representative sample of the customer group whose satisfaction is being measured. The sampling and survey must be performed strictly in accordance with sociological research standards. Data must be collected regularly and at clearly defined intervals. Depending on the industry, this interval is selected individually and depends on the frequency with which the customer uses the product and interacts with the organisation's business processes and staff.

2. Index calculation. This stage consists of analytical calculations to determine the average scores for the index characteristics (based on the responses collected in the previous stage), multiplying them by the weights assigned to these characteristics, and calculating the final index (including sub-indices and the main index).

It is evident that the challenges faced by the analyst at the first stage of data collection are similar to those described earlier. The second stage contains relatively few risks, except for the possibility that a manager might overlook the fact that the chosen calculation ideology

influences the resulting index value. In the case of a synergistic model, this may lead to a distorted weighting of certain characteristics of the evaluated customer experience.

Thus, the collection and management of CSI data requires strict compliance with the principles of sociological research, along with a focused attention on the chosen index methodology and its implications.

Areas of Application of CSI in Strategic Management and Business Modelling

The applications of CSI in strategic management and business modelling are far broader than might appear at first glance. At the very least, CSI can serve as a valuable analytical foundation for decision-making in the following areas:

1. Measuring customer satisfaction and improving it. This is the primary purpose for which the CSI tool was originally created. CSI helps to identify dissatisfied customers and the reasons behind their dissatisfaction, enabling targeted actions to improve satisfaction (e.g., contacting the dissatisfied customer, correcting mistakes, implementing corrective measures, etc.).

2. Quality management within the organisation. CSI provides an analytical foundation for strategic decisions concerning the quality of the organisation's performance as a whole—including product quality in the narrow sense, quality of supporting business processes, and personnel quality. CSI has a key analytical advantage over complaints analysis and other types of customer feedback: it not only identifies problematic characteristics, but also highlights those most important to the organisation's customer base (provided that all customer groups are adequately represented in the index). When combined with an assessment of the costs involved in addressing these issues, this prioritisation of significant characteristics enables highly effective strategic decision-making—directly impacting customer satisfaction and, therefore, competitiveness.

3. Business model innovation. Since CSI determines the importance of specific characteristics of the customer experience—especially when a discrete index model is used—it becomes a critical tool in business model innovation. Analysing the significance of different features allows organisations to modify their product, business processes and staff focus, emphasising competitive advantages in areas most valued by customers and downplaying less relevant ones. In this sense, CSI offers an invaluable foundation for business modelling as understood by authors such as W. Chan Kim and Renée Mauborgne (*2015*). It becomes particularly useful when the index is discrete, containing sub-indices for satisfaction with the product, business processes, and staff.

4. Development of a USP. Similar to its use in business modelling, CSI can inform the creation of a USP by reflecting the importance of various aspects of the customer experience. This enables businesses to focus on what matters most to customers and reduce attention to less important aspects (*Ilieska, 2013*). A discrete CSI model is especially advantageous here. Conducting a survey within a representative sample from the target cluster or segment may include competitors' customers, allowing for a CSI measurement of competing organisations and a comparative analysis of strengths and weaknesses. This enables the development of a USP tailored to actual market conditions. CSI can guide product adjustments that ignore low-importance features and achieve superiority in those most valued by the target audience.

5. Brand management. David Aaker, in his concept of brand equity, identified perceived brand quality as one of its key components (*Aaker, 1996*). The present author proposes breaking this down further into three components: perceived product quality (in the narrow sense), perceived quality of supporting business processes, and perceived quality of staff (*Kolyada, 2023, pp. 221–233*). This approach aligns closely with the previously described discrete CSI model. In terms of brand equity, the structure of these components mirrors that of the CSI sub-indices. The difference lies in the survey methodology: CSI involves surveying a representative sample of customers whose satisfaction is being measured, whereas brand equity measurement requires surveying a representative sample of customers across the entire target cluster or segment (including customers of competitors). Thus, CSI reflects how satisfied customers are with an organisation's performance (in terms of product, processes, and personnel), while the three brand equity components reflect the perception of all customers in the target segment (including those choosing competitors' products) regarding the quality of the organisation's performance.

In conclusion, CSI is a powerful strategic management and business modelling tool. It is effectively used not only in its original domain (customer satisfaction monitoring and organisational quality management), but also in areas that, at first glance, may seem unrelated to customer satisfaction. Its application significantly enhances the quality of strategic operations within an organisation.

Limitations of CSI Application

Despite its versatility and adaptability, the CSI cannot measure all aspects of customer satisfaction. One area where the use of CSI is not advisable—and may even be counterproductive—is the measurement of customer satisfaction with product pricing. Observations from the practice of CSI development show that when evaluating the importance of the "price" attribute, respondents typically assign it the highest level of importance compared to other characteristics determining product satisfaction. However, evidence suggests that the actual significance of price to customers is not always as high as they claim.

For instance, the housing market is largely driven by purchases made through mortgage financing. When mortgage loans are accessible, the price of residential property becomes a secondary concern, and even significant price increases do not deter buyers. Between 2014 and 2024, the average price per square metre of residential property in Russia rose from 51,700 to 97,500 roubles (an 88.59% increase) (*Dachenkova, 2024*), yet sales continued due to the availability of mortgages. A similar pattern is observed in the automotive market and other sectors where credit-based purchasing is common. Thus, respondents' claims that price is of utmost importance are clearly at odds with actual consumer behaviour.

Equally noteworthy are the results of CSI surveys that include the "price" attribute. It has been found that many customers who regularly make repeat purchases—thereby demonstrating loyalty—often express dissatisfaction with price. In reality, these customers are satisfied enough with the price to continue purchasing the product. Their expressed dissatisfaction is likely driven by a psychological desire to prompt price reductions by "complaining" that prices are too high. This behaviour does not reflect their actual satisfaction with pricing but is instead a strategic move aimed at gaining financial benefit. As such, these "complaints" should not be interpreted as genuine indicators of dissatisfaction.

Consequently, it is not advisable to include "satisfaction with price" as a component of CSI. Price satisfaction—or more accurately, price competitiveness—is worth assessing using alternative methods, such as comparative scoring that benchmarks the organisation's pricing against that of its competitors (*Kolyada, 2023, pp. 266–268*).

Thus, in developing and applying CSI, it is crucial to consider the psychological characteristics of customers and their ability to provide realistic evaluations across the various attributes that may be included in the index. Characteristics for which importance ratings or satisfaction assessments do not correspond to real behaviour is worth excluding on methodological grounds.

Discussion

Unfortunately, research on the use of CSI has predominantly relied on empirical methods. This is largely due to the closed nature of the corporate world, where concerns over commercial confidentiality often preclude the possibility of conducting comprehensive quantitative studies on the subject. As a result, the conclusions that can be drawn on this topic—including those presented in this article—are necessarily limited. When assessing the findings presented here, managers are advised to consider the specific characteristics of their sectors.

Nevertheless, the extensive empirical observations performed using qualitative methods, the results of which are detailed in this article, provide a sufficient basis for understanding the essence of the issue.

Conclusion

Analysis of CSI development and application across different sectors demonstrates that this tool is one of the most powerful available for an organisation's strategic development. For this reason, it has been incorporated—within a discrete model—into the business modelling and strategic planning methodology developed by the author of this article (*Kolyada, 2023*; *Kolyada & Plekhova, 2023*). Despite certain complexities in developing and maintaining this tool, CSI offers more opportunities for identifying problem areas and growth potential than other comparable instruments, such as the NPS.

However, CSI also presents several specific features that must be considered. During both its development and application, adherence to methodological requirements is essential. This includes correctly identifying the target cluster, segment, and client group whose satisfaction is being measured, as well as conducting thorough qualitative and quantitative research. When applying the tool, researchers must comply with standards for quantitative analysis and ensure that the original conceptual framework underpinning the index is reflected in the calculations.

CSI should be used to its full potential—across all areas where it can be beneficial: measuring customer satisfaction and making decisions to enhance it, managing organisational quality, innovating business models, developing USPs, and brand management. The application of CSI in these domains can significantly improve the effectiveness of business modelling, strategic planning, and strategic management within an organisation.

Finally, one must remain mindful of the limitations inherent to CSI. For example, measuring satisfaction with price using CSI is not recommended; other tools are worth employing for this purpose.

Overall, the use of CSI is not worth restricting to customer satisfaction measurement alone. In strategic work, its full potential should be harnessed across all the domains outlined in this article.

Conflict of Interest

The author declares that there is no conflict of interest.

References:

Aaker, D. A. (1996). *Building strong brands*. Free Press.

Dachenkova, T. (2024, February 19). How has the real estate market changed over the past 10 years. *Novostroy*. https://www.novostroy.ru/articles/market/kak-rynok-nedvizhimosti-izmenilsya-za-poslednie-10-let-sravnili-tseny-stavki-vliyanie-bankov-i-sdelali-prognozy/ (In Russ.)

Ilieska, K. (2009). *Services Marketing*. Bitola.

Ilieska, K. (2013). Customer Satisfaction Index – as a Base for Strategic Marketing Management. *TEM Journal*, *2*(4), 327–331.

Kim, W. C., & Mauborgne, R. (2015). *Blue ocean strategy: How to create uncontested market space and make competition irrelevant*. Harvard Business Review Press.

Kolyada, A. A. (2023). *Next level: strategic management of the new era. How to build an effective business model and develop an effective strategy for the growth of your company*. Moscow: Alpina PRO LLC, Eurasian School of Management and Administration LLC. EDN FUTPBY. (In Russ.)

Kolyada, A. A., & Plekhova, Y. O. (2023). Methodology for developing an organization's business model and forecasting its economic efficiency. *Theory and Practice of Social Development*, *8*(184), 101–112. EDN JWIWXI. (In Russ.)

Lavrova, A. P. (2024). The main methods of assessing customer satisfaction in modern conditions. *Humanities, Socio-Economic and Social Sciences*, *5*, 188–193. (In Russ.)

Reichheld, F. F. (2003). The one number you need to grow. *Harvard Business Review*, *81*(12), 46–54.

Tretyakov, V. P., Kolesneva, E. P., & Lyubetsky, P. B. (2005). *Market segmentation: Guidelines*. Gorky: Belarusian State Agricultural Academy. (In Russ.)

Romanova, N. A. [a][21]

ELECTROMYOGRAPHIC SIGNAL AS FEEDBACK FOR PELVIC FLOOR MUSCLE REHABILITATION AND TRAINING [10]

Abstract: In the present world, most people are engaged in routine office work. This factor contributes to high inactivity in the musculoskeletal system and the body. Disorders of the muscular structure and pelvic ligaments may also be caused by dyssynergic defecation, surgical intervention, degenerative disease, pregnancy and childbirth in women, muscle relaxants, narcotics, and similar factors. Therefore, developing physiotherapy methods and a fitness training plan is a highly relevant task today. The novelty of this research lies in developing a new approach to rehabilitating and training pelvic floor muscles using the electromyographic signal as biofeedback. The study object is the rehabilitation and training of pelvic floor muscles. The study subject is the method of rehabilitation and training of pelvic floor muscles using the EMG signal. The study aims to develop a physiotherapy method and a fitness training plan. The author applied general scientific methods such as analysis, experimentation, observation, and classification to achieve the purpose and address the study objectives. The study draws upon the works of foreign and Russian researchers in rehabilitation and physiotherapy of the pelvic floor muscles, processing and classification of electromyographic signals, and the evaluation and analysis of muscular activity. Within the framework of this study, a method of pelvic floor muscle training using biofeedback was proposed. The article presents the method of pelvic floor muscle training with biofeedback, illustrating what an EMG signal looks like and describing exercises based on electromyography. A 10-day training plan is provided. The method of assessing the patient's condition before and after the training is also described. The author concludes that the proposed method contributes to a positive change in the shape of the EMG signal. The paper presents EMG signals recorded before and after training, clearly showing significant changes in the shape and stability of muscle activity levels.

Keywords: physiotherapy, rehabilitation, electromyography, pelvic floor muscles.

Abbreviations:

EMG is electromyography,

RMS is root mean square.

Introduction

Phylogenetically, the pelvic floor represents a relatively ancient group of skeletal muscles, which, as humans adopted an upright posture, acquired several new vital roles or underwent adaptation of previously existing functions. The functional tasks of the pelvic floor include: supporting the contents of the abdominal cavity in a vertical position; participating in both voluntary and reflexive contraction of the urethra; narrowing the transverse diameter of the vagina and the urogenital opening; contributing to sexual functions; and ensuring the function of the terminal section of the digestive tract (*Jozwik et al., 2013*).

Pelvic floor dysfunction and pelvic organ prolapse are currently significant issues—even early manifestations of pelvic floor dysfunction can lead to a decline in sexual quality of life, reduced activity, and eventually to social isolation and decreased self-esteem. One of the most popular conservative methods for treating pelvic floor dysfunction is pelvic floor muscle

[a] Natalia A. Romanova, Researcher in Physiotherapy, IP Romanova Natalia. Moscow, Russia. ORCID 0009-0003-6832-9558. E-mail: Nr0718040@gmail.com

training. Pelvic floor muscle training is among the most widely used and promising conservative approaches to correcting pelvic floor dysfunction (*Samsonova et al., 2023*; *Rusina et al., 2024*; *Dobrokhotova et al., 2018*). Researchers also note that the skeletal muscles comprising the pelvic floor can be "trained" and "overtrained" to maintain pelvic floor function (*Woodley & Hay-Smith, 2021*).

Such training aims to improve the strength, endurance, and coordination of the pelvic floor muscles and to enhance support of the proximal urethra and the bladder neck (*Madokoro & Miaki, 2019*). Therefore, pelvic floor muscle training may be beneficial in the prevention of urogenital, reproductive, and sexual system disorders. Objective assessment of pelvic muscle activity is crucial for evaluating the condition and determining appropriate rehabilitation and treatment strategies (*Hay-Smith et al., 2024*).

Many researchers argue for integrating electromyography (EMG) recording alongside clinical examination and observation (*Dornowski et al., 2018*; *Dannecker et al., 2005*). The use of biofeedback based on surface EMG has proven helpful in facilitating the identification of pelvic floor muscle dysfunction symptoms (*Wang et al., 2024*; *Auchincloss et al., 2009*). Thus, the EMG signal can be used to classify the state of pelvic floor muscles and to provide feedback for designing targeted training programmes for their development.

It is worth noting that the EMG signal is complex; however, it directly correlates with muscle activity (*Chen et al., 2025*). This correlation makes surface EMG a valuable tool for diagnosing and training various muscle groups (*Richaud et al., 2024*).

This study will examine different methods of pelvic floor muscle training and investigate their effects on the development and stabilisation of pelvic floor muscle condition. The EMG signal will serve as the primary measure of muscle activity.

The study's novelty lies in its development of a new approach to pelvic floor muscle rehabilitation and training, using the EMG signal as feedback.

The study object is the rehabilitation and training of pelvic floor muscles.

The study subject is the pelvic floor muscle rehabilitation and training method using the EMG signal.

The study aims to develop physiotherapy methods and a fitness training programme.

To achieve this aim, the following objectives were set:

- study existing methods and approaches to physiotherapy and pelvic floor muscle rehabilitation;
- explore and identify key characteristics of the EMG signal;
- assess the electromyographic activity of the muscles before physiotherapy;
- conduct training using EMG and evaluate the electromyographic activity of the muscles after physiotherapy.

Methods and Materials

The following research methods were employed in the course of the study:

1. Analysis. The study includes an analysis of existing methods in the field of physiotherapy. An overview of EMG is provided, along with a breakdown of its features and properties. The primary methods used in pelvic floor physiotherapy are as follows:

- Biofeedback therapy is recommended for addressing urinary and faecal incontinence, vaginal wall prolapse, chronic pelvic pain, and sexual dysfunction.
- Electrical stimulation, aimed at restoring the pelvic floor following childbirth.
- Low-load exercises.
- Manual therapy.

2. Experiment. An experiment was conducted under specially created conditions to study electromyographic activity. The proposed method was tested on a 32-year-old female patient of average build with a usually developed musculoskeletal system. The experiment involved a series of training sessions using the proposed methods and EMG signals, comparing EMG signals recorded before and after the training programme.

3. Observation. Information about the condition of the subject's muscles was obtained through observation and the recording of significant changes. Prior to each training session, the trainer performed a non-invasive visual inspection of the vestibular vaginal mucosa using a camera. The balance between the anterior and posterior pelvic floor muscles was assessed.

4. Classification. The study identified features of the electromyographic signal that allow for its classification. Signal classification was performed using time-frequency domain characteristics. Key features such as zero-crossing, RMS variation, and amplitude power were identified.

The study drew upon several key sources, including the monograph by J.V. Basmajian *Muscles Alive: Their Functions Revealed by Electromyography*, which is considered foundational in electromyographic research. The book examines various muscles, describes measurement methods, and explores the nature of EMG signal generation.

The work by C. Auchincloss, T. Richaud, and Y. Wang explores the reliability of surface EMG recorded from pelvic floor muscles. This study is widely cited and supports the use of surface EMG in physiotherapy.

Jozwik Maciej provides a review of the anatomy and function of the female pelvic floor, with a focus on the effects of vaginal childbirth. The work surveys scientific findings on pelvic floor muscles and their condition post-delivery.

Another widely referenced publication is the narrative review by S.J. Woodley and E.J.C. Hay-Smith, "Narrative Review of Pelvic Floor Muscle Training for Childbearing Women—Why, When, What, and How", which discusses various changes to the pelvic floor during pregnancy and outlines training methods to prepare for childbirth.

Results

EMG Signal

This paragraph briefly describes what EMG is and how it can be used for pelvic floor muscle training. Surface EMG signals are one of the primary sources of neural signals (*Basmajian & De Luca, 1962*). Various EMG signal processing algorithms decode the user's action and generate a control signal for external devices or software.

Figure 1 (*1*) presents examples of EMG signals in the case of a relaxed muscle and during muscle activity. The graph in Figure 1 (*1*) shows that the onset of muscle activity significantly

increases the number of slope sign changes and the amplitude magnitude. At the same time, the number of zero crossings and the mean absolute value change only slightly (*Unanyan & Belov, 2019*). Therefore, one can derive a curve directly correlating with muscle activity using such characteristics as slope sign changes and amplitude. Figure 2 (*2*) illustrates the muscle state after EMG signal processing.

Assessment of EMG Values and Pelvic Floor Muscle Training

During the initial assessment, evaluating the overall condition of the pelvic floor muscles and the mucosal tissues is essential. This is conducted through an invasive examination using a camera, during which the condition of the mucosa at the vaginal introitus and the balance between the anterior and posterior muscle groups are assessed. This information enables the development of an appropriate training plan. Additionally, the assessment results help determine the patient's overall condition and rule out any potential adverse effects of physical exercise.

The next stage involves assessing the myo activity of the pelvic floor muscles. It is important to note that numerous factors can influence the EMG signal. For this procedure, it is assumed that the equipment filters the EMG signal and shields it from external magnetic fields and environmental interference. The patient must adhere to the following behavioural criteria:

1. The body must be relaxed.
2. The abdomen should be drawn in for proper function.
3. The legs and gluteal muscles should remain relaxed.
4. The upper thoracoabdominal diaphragm should maintain calm, steady breathing.

At this stage, the patient's myo activity is tested. The trainer instructs the patient to engage the anterior and posterior muscle groups and evaluates the EMG signal during this engagement. The patient is then asked to perform a light contraction of the muscles and maintain this activity level for seven minutes. During this time, the trainer observes the patient's general body state and corrects their behaviour, for example, addressing irregular breathing or tension in the legs and gluteal region—to ensure proper technique during the exercise. The EMG signal pattern during the static exercise is illustrated in Figure 3 (*3*). The aim is to teach the patient to activate the pelvic floor muscles without engaging other muscles or organs. A successful outcome is the patient acquiring the ability to use the pelvic floor muscles while keeping the rest of the body completely relaxed.

Once acceptable results have been achieved with the patient, a basic training routine is established. It consists of two exercises: one static and one dynamic. The static exercise involves tensing the muscles and maintaining the tension for a specific period, followed by relaxation. In this case, the patient is required to apply mild tension and hold it for 10 minutes. After that, the dynamic exercise is worth performing. The dynamic exercise involves tensing the muscles for 7 seconds and relaxation for 5 to 10 seconds. The dynamic exercise starts with ten repetitions of muscle tension; increasing the number of tension cycles by two in each subsequent session is recommended until the patient reaches 20 repetitions per exercise. Figure 4 (*4*) shows the EMG signal behaviour during the dynamic exercise.

Figure 4 shows that a threshold of 15 units has been selected, above which the patient must maintain the EMG signal during exertion. This threshold is individually tailored for each patient and can be adjusted during training. Next, a static exercise is repeated, during which the patient aims to engage primarily the posterior muscle groups; the contraction duration is five minutes. Ultimately, the training consists of the following sequence: static–dynamic–static exercise. It is recommended to perform 10 repetitions daily for 10 days.

Approbation

This training method was tested on a 32-year-old female patient of average build. After 10 days of training, the following changes were observed through video analysis:

1. Changes in the structure of the mucous membrane (small cracks and tears were eliminated).
2. The anterior and posterior muscles were toned.
3. Blood circulation improved.
4. The patient had varicose veins around the cervix, and after the training, a positive trend in the treatment of varicose veins was noted.
5. Changes in EMG.

One of the key results was the change in the EMG pattern. Over 10 days, the patient learned how to contract her muscles properly and, as a result, gained control over them. Figure 5 (*5*) clearly shows that the amplitude of the EMG noise significantly decreased. The patient can now "glide" at a certain level of load. In this case, the patient was required to maintain a signal at levels 9–10.

Comparing Figures 3 (*4*) and 5 (*5*), it can be concluded that the quality of the EMG signal has significantly improved. The amplitude of noise caused by the vibration of the muscle tissue has notably decreased. This suggests that the patient has significantly improved the physical condition of the pelvic floor muscles.

Discussion

During the work, it was found that the proposed method allows for positive dynamics in the development of the pelvic floor muscles. Biofeedback significantly accelerates the process of recovery, rehabilitation, or maintenance of pelvic floor muscles.

It is worth noting that the EMG signal, used as biofeedback, is highly susceptible to external influences, such as:

1. Electronic device noise.
2. Environmental noise, such as various parasitic electromagnetic fields.
3. Entering saturation mode.
4. Natural instability of the signal.

All these factors significantly complicate the training process and the use of the EMG signal. Additionally, the patient's psychosomatic state plays a crucial role. This issue was avoided in the experiment described in the work. However, the overwhelming majority of patients, influenced by their perceptions of the condition of the muscle or body as a whole, significantly reduce the effectiveness of the training.

It is worth noting that the training's results were less productive than the author had anticipated. Unfortunately, this was caused by an unoptimised training plan formulated for the patient.

In the future, it is planned to continue the research on the pelvic floor muscles and address the following questions:

How do dynamic and static training regimes affect the pelvic floor muscles and EMG signals in the long term?

How can EMG signals be displayed for the patient to increase the productivity of the training?

Can EMG signals be used to detect fatigue and dysfunction of individual fibres or the muscle as a whole?

Conclusion

Thus, the article discusses the method of pelvic floor muscle training using biological feedback. It demonstrates the appearance of the EMG signal and describes exercises involving electromyography. A 10-day training plan is provided. The method for assessing the patient's condition before and after the training is outlined. The graph shown in Figure 5 illustrates the positive impact of this training method on the pelvic floor muscles. After completing the 10-day training programme, the patient learned to work the front and back muscles separately. The condition of the mucosa at the vaginal vestibule significantly improved. The stability of the electromyographic signal during static exercises also greatly improved.

Conflict of interest

The author declares that there is no conflict of interest.

Appendix

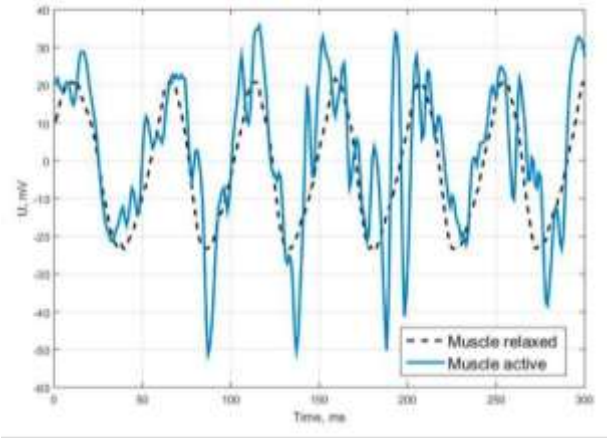

Figure 1. The form of EMG signal

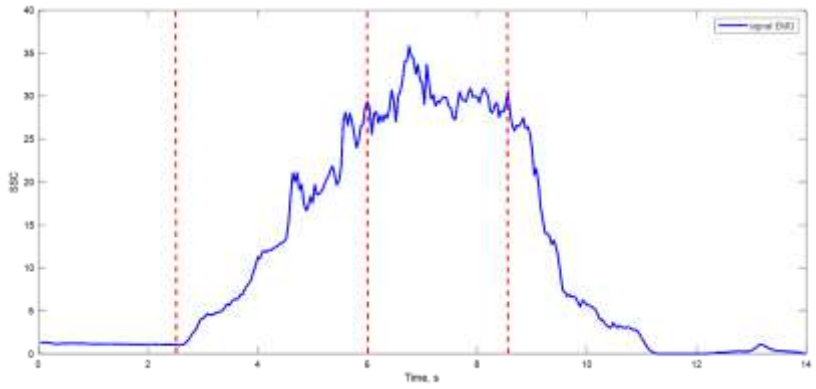

Figure 2. Changes in EMG characteristics during muscle activity: 0–2.5 sec.—muscle is relaxed, 2.5–6 sec.—gradual contraction, 6–8.5 sec.—sustained muscle activity, 8.5–14 sec.—relaxation.

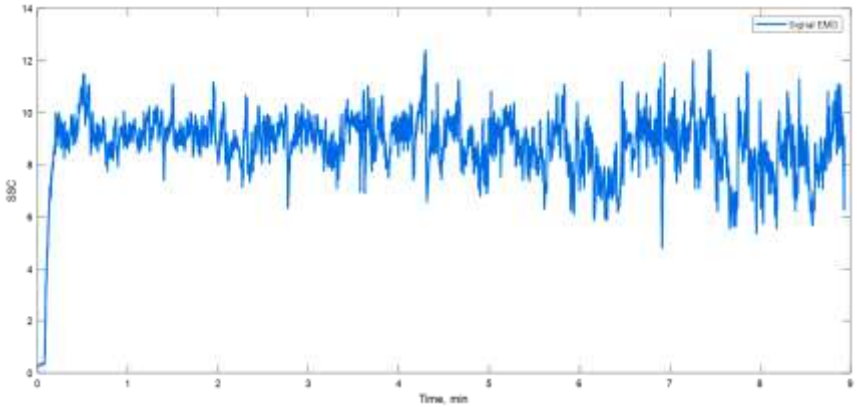

Figure 3. Static exercise

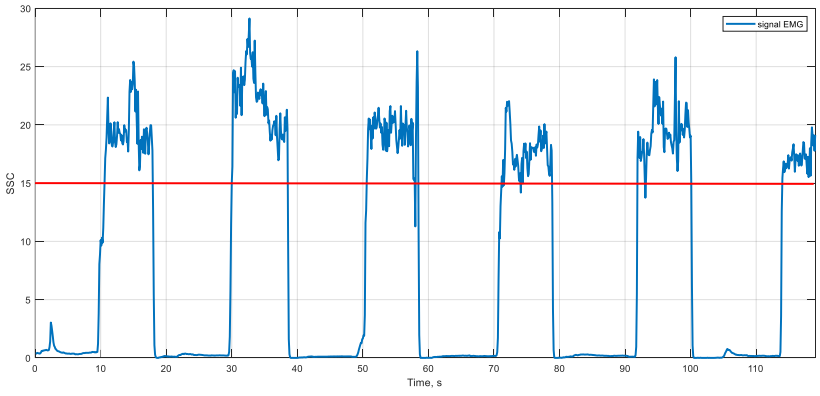

Figure 4. Static exercise

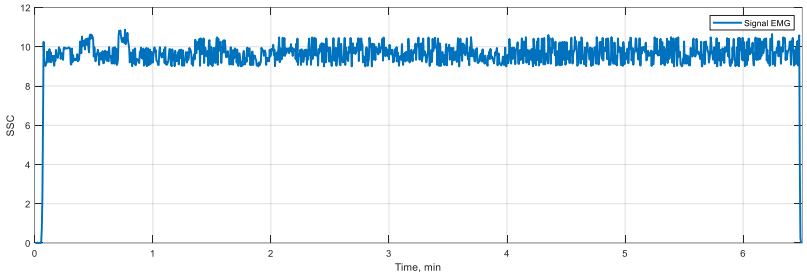

Figure 5. The view of EMG after 10-days training

References:

Auchincloss, C., & Mclean, L., (2009). The reliability of surface EMG recorded from the pelvic floor muscles. *Journal of Neuroscience Methods*, *183*, 85–96. https://doi.org/10.1016/j.jneumeth.2009.05.027

Basmajian, J. V., & De Luca, C. J. (1962). *Muscles alive: Their functions revealed by electromyography*. Baltimore: Williams & Wilkins.

Chen, C., Li, Dongxuan, & Xia, Miaojuan. (2025). A motor unit action potential-based method for surface electromyography decomposition. *Journal of NeuroEngineering and Rehabilitation*, *22*. https://doi.org/10.1186/s12984-025-01595-y

Dobrokhotova, Y. E., Nagieva, T., & Slobodyanyuk, B. A. (2018). A new approach to postpartum rehabilitation of patients with pelvic floor dysfunction. *Obstetrics and Gynecology*, 78–82. (In Russ.). https://doi.org/10.18565/aig.2018.7.78-82

Dornowski, M., Sawicki, P., Vereshchaka, I., Piernicka, M., Błudnicka, M., Worska, A., & Szumilewicz, A. (2018). Training-related changes of EMG activity of the pelvic floor muscles in women with urinary incontinence problems. *Neurophysiology*, *50*. https://doi.org/10.1007/s11062-018-9740-4

Dannecker, C., Wolf, V., Raab, R., Hepp, H., & Anthuber, C. (2005). EMG-biofeedback assisted pelvic floor muscle training is an effective therapy of stress urinary or mixed incontinence: a 7-year experience with 390 patients. *Arch Gynecol Obstet*, *273*(2), 93–97. https://doi.org/10.1007/s00404-005-0011-4

Hay-Smith, E., Starzec-Proserpio, M., Moller, B., Aldabe, D., Pazzoto Cacciari, L., & Pitangui, A., Vesentini, G., Woodley, S., Dumoulin, C., Frawley, H., Jorge, C., Morin, M., Wallace, S., & Weatherall, M. (2024). Comparisons of approaches to pelvic floor muscle training for urinary incontinence in women. *The Cochrane Database of Systematic Reviews*, *12*. CD009508. https://doi.org/10.1002/14651858.CD009508.pub2

Jozwik, M., Jóźwik, M., Adamkiewicz, M., Szymanowski, P., & Jóźwik, M. (2013). An updated overview on the anatomy and function of the female pelvic floor, with emphasis on the effect of vaginal delivery. *Medycyna Wieku Rozwojowego*, *17*, 18–30. (In Pol.)

Madokoro, S, & Miaki, H. (2019). Relationship between transversus abdominis muscle thickness and urinary incontinence in females at 2 months postpartum. *Journal of Physical Therapy Science*, *31*(1), 108–111. https://doi.org/10.1589/jpts.31.108

Richaud, T., Lacaze, K., Fassio, A., Nicolas, P., Ourliac, M., Hennart, B., Ina, J., Sonnery-Cottet, B., & Cavaignac, E. (2024). How biofeedback with surface EMG can contribute to the diagnosis and treatment of AMI in the knee. *Video Journal of Sports Medicine*, *4*. https://doi.org/10.1177/26350254241241084

Rusina, E., Zhevlakova, M., Shelayeva, E., & Yarmolinskaya, M. (2024). Differentiated approach to the choice of therapy for stress urinary incontinence in women with pelvic floor dysfunction. *Journal of Obstetrics and Women's Diseases*, *73*, 63–76. https://doi.org/10.17816/JOWD629472

Samsonova, I., Gaifulin, R., Toktar, L., Orazov, M., Kamarova, Z., Li, K., & Pak, V. (2023). Pelvic floor muscle training as a method of prevention and treatment of pelvic floor dysfunction and genital prolapse. *RUDN Journal of Medicine*, *27*, 39–45. https://doi.org/10.22363/2313-0245-2023-27-1-39-45

Unanyan, N. N., & Belov, A. A. (2019). Signal-Based Approach to EMG-Sensor Fault Detection in Upper Limb Prosthetics. *The 20th International Carpathian Control Conference (ICCC)*, 1–6.

Wang, Y., Wang, J., & Li, W. (2024). Basic vs electromyographic biofeedback–assisted pelvic floor muscle training for the improvement of sexual function after total hysterectomy: a prospective study. *Sexual Medicine*, *12*, qfae034. https://doi.org/10.1093/sexmed/qfae034

Woodley, S. J., & Hay-Smith, E. J. C. (2021). Narrative review of pelvic floor muscle training for childbearing women-why, when, what, and how. *International Urogynecology Journal*, *32*(7), 1977–1988. PMID: 33950309. https://doi.org/10.1007/s00192-021-04804-z

Authors:

[1] *Alexander Buychik*, Doctor of Economical Sciences, Ph.D. in Social Sciences, Supervisor, European Institute for Innovation Development, Tuculart Holding. Ostrava, Czech Republic.
E-mail: info@buychik.eu
ORCID 0000-0002-2542-4198

[2] *Anisiia Tomanek*, Master of Social and Cultural Sciences. Chief Director, European Institute for Innovation Development, Tuculart Holding. Ostrava, Czech Republic.
E-mail: ex@tuculart.eu

[3] *Elena Petkova*, Associate Professor, Ph.D. in Economics and Management of Tourism, Department of Geography of Tourism, Faculty of Geology and Geography, Sofia University "St. Kliment Ohridski". Sofia, Bulgaria.
E-mail: epetkova@gea.uni-sofia.bg
ORCID 0000-0003-3232-6104

[4] *Maksim V. Bakhtin*, Professor, Doctor of Philosophical Sciences, International Business Professors Club. Ragusa, Italy.
ORCID 0000-0003-1366-3009.
E-mail: dr.maximebakhtin@gmail.com

[5] *Ziiabidin Aidarov*, Professor, Doctor of Medical Sciences, I.K. Akhunbaev Kyrgyz State Medical Academy. Bishkek, Kyrgyzstan.
E-mail: aydarov.kgma@gmail.com
ORCID 0000-0003-2323-5702

[6] *Cholpon Usupova*, Doctor of Philosophical Sciences, Department Head, Department of Philosophy and Social Sciences, I.K. Akhunbaev Kyrgyz State Medical Academy. Bishkek, Kyrgyzstan.
E-mail: usupova.tcholpon@yandex.ru
ORCID 0000-0001-7231-2642

[7] *Rachat Satybaldieva*, Senior Lecturer, Department of Philosophy and Social Sciences, I.K. Akhunbaev Kyrgyz State Medical Academy. Bishkek, Kyrgyzstan.
E-mail: satybaldieva.rakhat@mail.ru
ORCID 0000-0002-0429-3192

[8] *Ainura Barynbaeva*, Researcher in Medicine, Kyrgyz State Medical College. Osh, Kyrgyzstan.
E-mail: abarynbaeva75@mail.ru
ORCID 0000-0001-8062-7193

[9] *Ainura Kulzhanova*, Researcher in Medicine, Deputy Dean, Faculty of Postgraduate Medical Education, I.K. Akhunbaev Kyrgyz State Medical Academy. Bishkek, Kyrgyzstan.
E-mail: kuljanovaa@mail.ru
ORCID 0000-0002-1184-9371

[10] *Chen Dashuai*, Doctoral Student of the Department of Philosophy, Theory and History of Culture, Kyrgyz National University. Bishkek, Kyrgyz Republic.
E-mail: 469718738@qq.com
ORCID 0009-0005-3977-4446

[11] *Marat Abdyldaev*, Researcher, National Institute for Strategic Initiatives, Kyrgyz National University. Bishkek, Kyrgyz Republic.
E-mail: 3martab.abd@mail.ru

[12] *Rakhat Satybaldieva*, Senior Lecturer, Department of Philosophy and Social Sciences, I.K. Akhunbaev Kyrgyz State Medical Academy, Bishkek, Kyrgyz Republic.
E-mail: satybaldieva.rakhat@mail.ru
ORCID 0000-0002-0429-3192

[13] *Rosen Solakov*, Ph.D. Student, Department of Civil Law Sciences, Faculty of Law, Plovdiv University "Paisii Hilendarski". Plovdiv, Bulgaria.
E-mail: rosen.solakov@uni-plovdiv.bg

[14] *Iulian Grigoriu*, Ph.D. Student, "Dunarea de Jos" University of Galati. Galaţi, Romania.
E-mail: iulian_grigoriu@yahoo.com

[15] *Nikolay S. Rybakov*, Doctor of Philosophical Sciences, Professor of the Department of Philosophy and Theology, Professor, Pskov State University. Pskov, Russia.
E-mail: nik-rybakov@yandex.ru
ORCID 0000-0003-1007-6001

[16] *Tatyana V. Torubarova*, Doctor of Philosophy, Professor, Department of Philosophy, Kursk State University. Kursk, Russia.
E-mail: ttorubarova@rambler.ru
ORCID 0000-0001-7319-6428

[17] *Natalya A. Yarmolich*, Candidate of Philosophical Sciences, Associate Professor, Department of Philosophy and Theology, Pskov State University. Pskov, Russia.
E-mail: yarmol92@yandex.ru
ORCID 0000-0001-7101-1215

[18] *Elena N. Tkach*, Candidate of Psychological Sciences, Associate Professor, Pacific National University. Khabarovsk, Russia.
ORCID 0000-0003-0324-9330

[19] *Lyubov V. Kochneva*, Ph.D. in Psychological Sciences, Associate Professor, Department of Sociology, Psychology and Social Management, National Research University "Moscow Aviation Institute". Moscow, Russia.
E-mail: shafrans@mail.ru
ORCID 0000-0002-7439-7798

[20] *Andrey A. Kolyada*, Nizhny Novgorod, Doctor of Business Administration, Rector, Eurasian Management and Administration School (EMAS Business School), Applicant at National Research Lobachevsky State University. Nizhny Novgorod, Russia.
E-mail: kolyada@emasrussia.ru
ORCID 0009-0005-9725-9370

[21] *Natalia A. Romanova*, Researcher in Physiotherapy, IP Romanova Natalia. Moscow, Russia.
E-mail: Nr0718040@gmail.com
ORCID 0009-0003-6832-9558

Citations in APA

[1] Buychik, A., & Tomanek, A. (2025). The application of digital graphics software in cultural heritage restoration: documentation, reconstruction, and visualisation. *Actual Issues of Modern Science. The Proceedings of the European Institute for Innovation Development International Conference*, *36*, 7–43. Ostrava–Ragusa. https://doi.org/10.47451/her2025-05-01

[2] Petkova, E. (2025). A system of indicators for monitoring sustainable tourism development of tourism destinations. *Actual Issues of Modern Science. The Proceedings of the European Institute for Innovation Development International Conference*, *36*, 44–58. Ostrava–Ragusa. https://doi.org/10.47451/ecn2025-02-01

[3] Bakhtin, M. V. (2025). Subject of social memory and the transmission of historicity. *Actual Issues of Modern Science. The Proceedings of the European Institute for Innovation Development International Conference*, *European Scientific e-Journal*, *36*, 59–68. Ostrava–Ragusa. https://doi.org/10.47451/phi2025-04-02

[4] Aidarov, Z., Usupova, Ch., Satybaldieva, R., Barynbaeva, A., & Kulzhanova, A. (2025). Bioethics as a responsible attitude to the technical development of medicine. *Actual Issues of Modern Science. The Proceedings of the European Institute for Innovation Development International Conference*, *European Scientific e-Journal*, *36*, 69–78. Ostrava–Ragusa. https://doi.org/10.47451/phi2025-04-01

[5] Dashuai, C., Usupova, C., Abdyldaev, M., & Satybaldieva, R. (2025). Problems of cultivating ideological security in the educational environment. *Actual Issues of Modern Science. The Proceedings of the European Institute for Innovation Development International Conference*, *European Scientific e-Journal*, *36*, 79–92. Ostrava–Ragusa. https://doi.org/10.47451/phi2025-04-03

[6] Solakov, R. (2025). General characteristics of property protection. *Actual Issues of Modern Science. The Proceedings of the European Institute for Innovation Development International Conference*, *European Scientific e-Journal*, *36*, 93–106. Ostrava–Ragusa. https://doi.org/10.47451/jur2025-05-01

[7] Grigoriu, I. (2025). Meaning, relation, identity and generality in the Tractarian. *Actual Issues of Modern Science. The Proceedings of the European Institute for Innovation Development International Conference*, *European Scientific e-Journal*, *36*, 107–124. Ostrava–Ragusa. https://doi.org/10.47451/phi2025-04-05

[8] Rybakov, N. S., Torubarova, T. V., Yarmolich, N. A., Tkach, E. N., & Kochneva, L. V. (2025). Human security in digital environment. *Actual Issues of Modern Science. The Proceedings of the European Institute for Innovation Development International Conference*, *European Scientific e-Journal*, *36*, 125–136. Ostrava–Ragusa. https://doi.org/10.61726/2704.2025.23.74.001

[9] Kolyada, A. A. (2025). Features of applying the customer satisfaction index (CSI) in business modelling, strategic planning, and strategic management. *Actual Issues of Modern Science. The Proceedings of the European Institute for Innovation Development International Conference*, *European Scientific e-Journal*, *36*, 137–144. Ostrava–Ragusa. https://doi.org/10.61726/8260.2025.53.34.001

[10] Romanova, N. A. (2025). Electromyographic signal as feedback for pelvic floor muscle rehabilitation and training. *Actual Issues of Modern Science. The Proceedings of the European Institute for Innovation Development International Conference*, *36*, 145–153. Ostrava–Ragusa.
https://doi.org/10.61726/7877.2025.76.41.001

European Scientific e-Journal

EU, Czech Republic, Ostrava

Publishers
European Institute for Innovation Development
Tuculart Edition

Right to conduct publication activities
IČ: 14207052

Date of Issue
May 30, 2025

EUROPEAN SCIENTIFIC e-JOURNAL
ISSN 2695-0243
DOI 10.47451/col-036-2025